GE
Intelligent Platforms

Programmable Control Products

VersaSafe

VersaPoint* Module: IC220SDL543

SAFE INPUT, 24VDC POSITIVE LOGIC, 8PT

User's Manual, GFK-2730

September 2011

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User‘s manual
VersaPoint module with safe digital inputs

2011-09-29

Catalog No.: GFK-2730

Revision: 05

This user manual is valid for:

Catalog No.:	Revision
IC220SDL543	HW/FW: 00/201
	HW/FW: 00/202

Please observe the following notes

In order to ensure the safe use of the product described, you have to read and understand this manual. The following notes provide information on how to use this manual.

User group of this manual

The use of products described in this manual is oriented exclusively to qualified electricians or persons instructed by them, who are familiar with applicable standards and other regulations regarding electrical engineering and, in particular, the relevant safety concepts.

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This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

DANGER
This indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING
This indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION
This indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

The following types of messages provide information about possible property damage and general information concerning proper operation and ease-of-use.

NOTE
This symbol and the accompanying text alerts the reader to a situation which may cause damage or malfunction to the device, either hardware or software, or surrounding property.

This symbol and the accompanying text provides additional information to the reader. It is also used as a reference to other sources of information (manuals, data sheets, literature) on the subject matter, product, etc.

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Published by

GE Intelligent Platforms. Inc
2500 Austin Dr.
Charlottesville
Virginia

Phone (+1) 800-433-2682
Fax (+1) 780-420-2047

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1 For your safety

Purpose of this manual

The information in this document is designed to familiarize you with how the IC220SDL543 safety module works, its operating and connection elements, and its parameter settings. This information will enable you to use the IC220SDL543 module within a VersaSafe or PROFIsafe system according to your requirements.

Validity of the user manual

This manual is only valid for the IC220SDL543 module in the version indicated on the inner cover page.

1.1 General safety notes

WARNING: Depending on the application, incorrect handling of the safety module can pose serious risks for the user

When working with the safety module within the VersaSafe or PROFIsafe system, please observe all the safety notes included in this section.

Requirements

Knowledge of the following is required:

- The non-safety-related target system (e.g., PROFIBUS, PROFINET)
- The VersaSafe or PROFIsafe system
- The components used in your application
- The VersaPoint product range
- Operation of the software tools used
- Safety regulations in the field of application

Qualified personnel

In the context of the use of the VersaSafe or PROFIsafe system, the following operations may only be carried out by qualified personnel:

- Planning
- Configuration, parameterization, programming
- Installation, startup, servicing
- Maintenance, decommissioning

This user manual is therefore aimed at:

- Qualified personnel who plan and design safety equipment for machines and systems and are familiar with regulations governing safety in the workplace and accident prevention.
- Qualified personnel who install and operate safety equipment in machines and systems.

In terms of the safety notes in this manual, qualified personnel are persons who, because of their education, experience and instruction, and their knowledge of relevant standards, regulations, accident prevention, and service conditions, have been authorized to carry out any required operations, and who are able to recognize and avoid any possible dangers.

Documentation

You must observe all information in this manual as well as in the documents listed in "Documentation" on page 1-6.

Safety of personnel and equipment

The safety of personnel and equipment can only be assured if the safety module is used correctly (see "Correct usage" on page 1-5).

Error detection

Depending on the wiring and the corresponding setting of the safe input module parameters, the VersaSafe or PROFIsafe system can detect various errors within the safety equipment.

Do not carry out any repairs

Repair work may not be carried out on the safety module.

In the event that an error cannot be removed, please contact GE Intelligent Platforms immediately, engage a service engineer or send the faulty module directly to GE Intelligent Platforms.

Do not open the housing/security seal

It is strictly prohibited to open the safety module housing. In order to prevent the manipulation of the safety module and to detect the unauthorized opening of the safety module, a security seal is applied to the module. This security seal is damaged in the event of unauthorized opening. In this case, the correct operation of the safety module can no longer be ensured.

Measures to prevent incorrect connection and polarity reversal

Take measures to prevent the incorrect connection, polarity reversal, and manipulation of connections.

1.2 Electrical safety

WARNING: Hazardous body currents and the loss of functional safety

Disregarding instructions for electrical safety may result in hazardous body currents and the loss of functional safety.

In order to ensure electrical safety, please observe the following points.

Direct/indirect contact

Protection against direct and indirect contact according to VDE 0100 Part 410 must be ensured for all components connected to the system. In the event of an error, parasitic voltages must not occur (single-fault tolerance).

This can be achieved by:

– Using power supply units with safe isolation (PELV).
– Decoupling circuits, which are not PELV systems, using optocouplers, relays, and other components, which meet the requirements of safe isolation.

Power supply units for 24 V supply

Only use power supply units with safe isolation and PELV according to EN 50178/VDE 0160 (PELV). This prevents short circuits between primary and secondary sides.

Make sure that the output voltage of the power supply does not exceed 32 V even in the event of an error.

Insulation rating

When selecting the operating equipment, please take into consideration the contamination and surge voltages, which may occur during operation.

The IC220SDL543 module is designed for surge voltage category II (according to DIN EN 60664-1). If you expect surge voltages in the system, which exceed the values defined in surge voltage category II, take into consideration additional measures for voltage limitation.

Installation and configuration

Please observe the instructions for installing and configuring the system (see "Documentation" on page 1-6).

WARNING: Depending on the application, incorrect installation and upgrades can pose serious risks for the user

The user is obliged to design the devices used and their installation in the system according to these requirements. This also means that existing plants and systems retrofitted with VersaSafe or PROFIsafe must be checked and tested again in this respect.

1.3 Safety of the machine or system

The machine/system manufacturer and the operator are solely responsible for the safety of the machine or system and the implemented application, in which the machine or system is used. The Machinery Directive must thus be observed.

Draw up and implement a safety concept

In order to use the safety module described in this document, you must have drawn up an appropriate safety concept for your machine or system. This includes a hazard and risk analysis according to the directives and standards specified in "Directives and standards" on page 1-5, as well as a test report (checklist) for validating the safety function (see "Appendix: Checklists" on page C-1).

VersaSafe: Please refer to the documentation for the configurable safety module used.

The target safety integrity level (SIL according to EN 61508, SIL CL according to EN 62061 or performance level and category according to EN ISO 13849-1) is ascertained on the basis of the risk analysis. The safety integrity level ascertained determines how to connect and parameterize the safety module within the overall safety function.

Within a VersaSafe or PROFIsafe system, the safety module can be used to achieve safety functions with the following requirements depending on the conditions of use:

– Up to SIL 3 according to standard EN 61508
– Up to SIL CL 3 according to standard EN 62061
– Up to Cat. 4/PL e according to standard EN ISO 13849-1

Check hardware and parameterization

Carry out a **validation** every time you make a safety-related modification to your overall system.

Use your test report to ensure that:

– The safe devices are connected to the correct safe sensors and actuators
– The safe input and output devices have been parameterized correctly
– The variables have been linked to the safe sensors and actuators correctly (single-channel or two-channel)

1.4 Directives and standards

The manufacturers and operators of machines and systems, in which the IC220SDL543 module is used, are responsible for adhering to all applicable directives and legislation.

For the standards observed by the module, please refer to the certificate issued by the approval body and the EC declaration of conformity. These documents are available on the Internet at http://support.ge-ip.com.

1.5 Correct usage

Only use the VersaSafe or PROFIsafe system in accordance with the instructions in this section.

The IC220SDL543 safety module is designed exclusively for use in a VersaSafe or PROFIsafe system.
It can only perform its safety-related tasks within the system if it has been integrated into the execution process correctly and in such a way as to avoid errors.

You must observe all information in this manual as well as in the documents listed in "Documentation" on page 1-6. In particular, only use the module according to the technical data and ambient conditions specified in Section 11, "Technical data and ordering data" on page 11-1 and onwards.

Within a VersaSafe or PROFIsafe system, the safety module can be used to achieve safety functions with the following requirements depending on the conditions of use:

– Up to SIL 3 according to standard EN 61508
– Up to SIL CL 3 according to standard EN 62061
– Up to Cat. 4/PL e according to standard EN ISO 13849-1

It is designed for connecting single-channel or two-channel sensors, which can be used in association with safety technology.
For example, the module can be used in the following applications:

– Single or two-channel emergency stop or safety door equipment
– Applications with enable button
– Applications with two-hand control devices
– Applications with mode selector switches
– As secondary switchgear for safety-related optical data links
– Safety circuits according to EN 60204 Part 1

1.6 Documentation

Latest documentation

Make sure you always use the latest documentation. Changes or additions to this document can be found on the Internet at http://support.ge-ip.com.

VersaSafe

When working on the VersaSafe system and its components, you must always keep this user manual and other items of product documentation to hand and observe the information therein.

User manuals:

– For the controller used
– For VersaSafe I/O modules
– For VersaSafe function blocks

Please also observe the relevant information about the bus system used.

PROFIsafe

When working on the PROFIsafe system and its components, you must always keep this user manual and other items of product documentation to hand and observe the information therein.

User manuals:

– For the safe controller used
– For PROFIsafe I/O modules
– For PROFIsafe function blocks

Please also observe the relevant information about PROFIBUS, PROFINET, and PROFIsafe, which is available on the Internet at www.profisafe.net.

VersaPoint product range

GFK-2736
Automation terminals of the VersaPoint product range (configuration and installation)

Documentation for the Network Interface Unit (NIU) used

1.7 Abbreviations used

Table 1-1 Abbreviations used

Abbreviation	Meaning	Standard	Example
SIL	Safety integrity level	EN 61508	SIL 2, SIL 3
SIL CL	SIL claim limit	EN 62061	SIL CL 3
Cat.	Category	EN ISO 13849-1	Cat. 2, Cat. 4
PL	Performance level	EN ISO 13849-1	PL e, PL d

Table 1-2 Abbreviations used

Abbreviation	Meaning
PELV	Protective extra-low voltage A circuit in which the voltage cannot exceed 30 V AC, 42.4 V peak value or 60 V DC under normal conditions, and under single-fault conditions, except earth faults in other circuits. A PELV circuit is like a SELV circuit, but is connected to protective earth ground. (According to EN 61131-2)
EUC	Equipment under control
OSSD	OSSD Output signal switching device OSSD is the part of electrosensitive protective equipment, which is connected to the machine control system and switches off if the sensor part responds during correct operation.

For terms and abbreviations used for PROFIsafe, please refer to "Appendix: PROFIsafe terms used in the manual" on page A-1.

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2 Product description

2.1 Brief description of the safety module

The IC220SDL543 module is an input module, which is designed for use within a VersaPoint station.

The IC220SDL543 safety module can be used as part of a VersaPoint station at any point within a VersaSafe or PROFIsafe system.

The transmission speed of the VersaPoint local bus can be set to 500 kbaud or 2 Mbaud on the safety module using switches.
One transmission speed must be used seamlessly in the relevant VersaPoint station in a **VersaSafe** or **PROFIsafe system**.

The module has a 10-pos. DIP switch, which is used to set the VersaSafe or PROFIsafe address.

The module has four safe digital inputs for two-channel assignment or eight safe digital inputs for single-channel assignment.

The inputs can be parameterized according to the application and enable the integration of sensors in the VersaSafe system or in the PROFIsafe system.

Within a VersaSafe or PROFIsafe system, the IC220SDL543 safety module can be used to achieve safety functions with the following requirements:

– Up to SIL 3 according to standard EN 61508
– Up to SIL CL 3 according to standard EN 62061
– Up to Cat. 4/PL e according to standard EN ISO 13849-1

2.2 Structure of the safety module

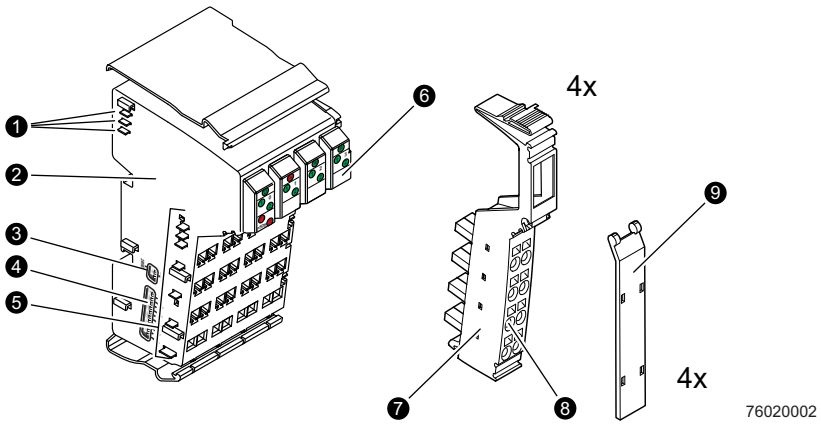

Figure 2-1 Structure of the safety module

1 Data jumpers (local bus)

2 Electronics base with labeling including hardware/firmware version designation (not shown)

3 Switch for setting the transmission speed and operating mode

4 Switch for setting the protocol and address

For more detailed information about setting the switches, please refer to "Setting the DIP switches" on page 4-2.

5 Potential jumper

6 Diagnostic and status indicators; for assignment and meaning see "Local diagnostic and status indicators" on page 2-8

7 VersaPoint connector; for assignment see "Terminal point assignment" on page 3-3

8 Terminal points

9 Labeling field

2.3 Housing dimensions

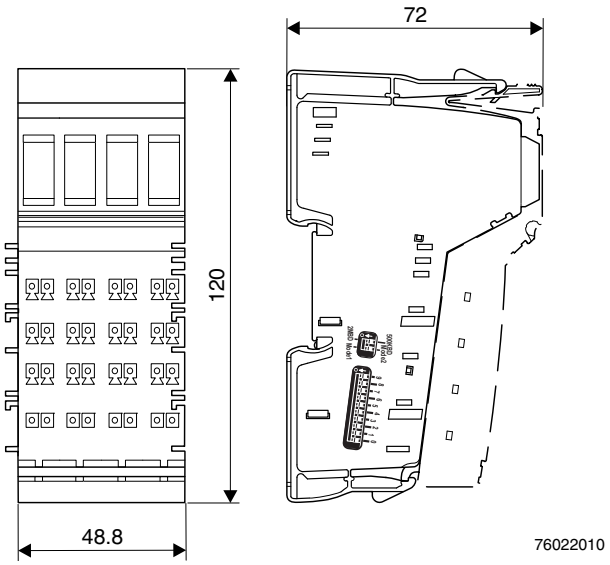

Figure 2-2 Housing dimensions (in mm)

2.4 Safe digital inputs and clock outputs UT1 and UT2

2.4.1 Safe digital inputs

The safety module has four safe digital inputs for two-channel assignment or eight safe digital inputs for single-channel assignment. The supply voltage for the inputs can be provided externally or via the clock outputs.

Technical data

For the technical data for the safe inputs, please refer to page 11-4.

Parameterization

The individual safe digital inputs of a safety module can be parameterized differently. This means that the inputs can be adapted to various operating conditions and different safety integrity levels can be implemented (SIL, SIL CL, Cat., PL).

The safety integrity level (SIL, SIL CL, Cat., PL) and error detection that can be achieved depend on the parameterization, the structure of the sensor, and the cable installation (see "Connection examples for safe inputs" on page 7-1).

For information about the parameterization of the inputs, please refer to "Parameterization of the safe inputs" on page 5-3.

Diagnostics

Diagnostics are provided via both the local diagnostic indicators and the diagnostic messages, which are transmitted to the safe controller (PROFIsafe) or to a configurable safety module (VersaSafe).

For information about the diagnostic messages of the inputs, please refer to "Safe digital input errors" on page 9-3.

CAUTION: Diagnostic data is not safety-related
Do not use the diagnostic data to execute safety-related functions or actions.

Requirements for controlling devices/sensors

The error detection of the module varies depending on the parameterization. This results in specific requirements for the sensors.

- To acquire input signals, the signal duration must be greater than the parameterized filter time.
- The sensors must be suitable for the application.
  Only use appropriately qualified sensors (suitable for the required category, SIL, SIL CL, PL).
- Use switches with a positive opening contact according to IEC 60947-5-1. Part 5 of this standard includes a description of the specific requirements for control switches with a positive opening contact. All positive opening control switches, which meet these specific requirements, are marked with the following symbol:

- Use reliable components. These include, for example:
  - Mechanical position switches with personal protection function with positive opening contact according to EN 60947-5-1
  - Cam-operated switches with positive opening contact
  - Emergency stop buttons/cable-operated switches with positive opening contact according to EN 60947-5-1
- Controlling devices can be evaluated on a single-channel or two-channel connection depending on the application.
- Under certain circumstances, switches (e.g., for position monitoring) must be designed redundantly depending on the risk.
- In order to achieve Cat. 3/Cat. 4 SIL 3/SIL CL 3 or PL d or e, controlling devices must usually be designed redundantly.
- Please observe any special environmental requirements in your application when selecting the controlling devices.
- Please observe the applicable C standards in your application (e.g., EN 1010), in which, for example, the number of controlling devices required to achieve a particular category is specified.

2.4.2 Clock outputs UT1 and UT2

The module has two independent clock outputs. They provide the supply voltage for the safe inputs. Each of these clock outputs can provide a pulse pattern to detect cross circuits and short circuits in the external wiring of the inputs. Intelligent sensors can also be supplied by the clock outputs. Depending on the application, both clock outputs can be parameterized differently.

Parameterization

For information about the parameterization of the clock outputs, please refer to "Parameterization of clock outputs UT1 and UT2" on page 5-7.

The clock outputs are also switched on and monitored when not parameterized. If a short circuit occurs at a clock output when it is in this state, the clock output is switched off. This is indicated by the local diagnostic LED.

To exit the error, parameterize the device and acknowledge the error message.

Technical data

For the technical data for the clock outputs, please refer to page 11-5.

Behavior in the event of an error

In the event of short circuit to GND or overload of the clock outputs, the clock outputs are switched off. At the same time, the error is indicated at the UT1 and/or UT2 LEDs and a diagnostic message is generated at the safe controller (PROFIsafe) or at a configurable safety module (VersaSafe). This error must be acknowledged so that the system can be started up again following error removal.

Error detection

Error detection depends on both the parameterization of the clock outputs and which input is assigned to which clock output. As there are two clock outputs for eight inputs, there may be reciprocal effects between the inputs.

Diagnostics

Diagnostics are provided via both the local diagnostic indicators and the diagnostic messages, which are transmitted to the safe controller (PROFIsafe) or to a configurable safety module (VersaSafe).
For information about the diagnostic messages of the clock outputs, please refer to "Clock output UT1 and UT2 errors" on page 9-5.

CAUTION: Diagnostic data is not safety-related

Do not use the diagnostic data to execute safety-related functions or actions.

2.5 Connection options for sensors depending on the parameterization

Sensors that meet various safety requirements depending on the parameterization can be connected to the inputs. For connection examples, please refer to Section 7, "Connection examples for safe inputs".

The maximum achievable SIL/SIL CL/Cat./PL is specified in the table.
In order to achieve this:

– Observe the information in the connection examples (see Section 7, "Connection examples for safe inputs")
– Observe the requirements of the standards with regard to the external wiring and the sensors to be used to achieve a SIL/SIL CL/Cat./PL (see "Measures required to achieve a specific safety integrity level" on page 7-3)

	Input										
Connection to the VersaPoint connectors	Single-channel sensor or redundant sensor			Two-channel redundant controlling device/sensor							Intelligent sensor
Input signal				Equivalent				Non-equivalent			See separate documentation for intelligent sensors
Clocking (UT1, UT2)	With	Without		2x	1x	Without		2x	1x	Without	
Sensors that can be connected:											
– Contact-based	Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes	
– With OSSD outputs	No		Yes	No	No		Yes	No	No	No	
Achievable SIL/SIL CL/Cat./PL	SIL 2 SIL CL 2 Cat. 3* PL d	SIL 2 SIL CL 2 Cat. 2 PL d	SIL 2 SIL CL 2 Cat. 2 PL d	SIL 3 SIL CL 3 Cat. 4 PL e	SIL 3 SIL CL 3 Cat. 4 PL e	SIL 3 SIL CL 3 Cat. 3 PL d	SIL 3 SIL CL 3 Cat. 4** PL e	SIL 3 SIL CL 3 Cat. 4 PL e	SIL 3 SIL CL 3 Cat. 4 PL e	SIL 3 SIL CL 3 Cat. 3 PL d	
For connection example, see page	7-6	7-8	7-10	7-15	7-17 7-20 7-23	7-26	7-29	7-34	7-37 7-40 7-43	7-45	

Key:

* Cat. 3 can only be achieved with a redundant sensor.

** The category that can be achieved depends on the sensor used.

Clocking

The clocking for the inputs is provided when clock outputs UT1 and UT2 are parameterized accordingly. The parameterization of UT1 and UT2 applies to the entire module. When parameterizing the inputs, specify which clock output is assigned to which input.

For two-channel inputs there are various options for assignment:

2x:	Both channels are assigned different clock outputs with clocking switched on.
1x:	Only one channel is assigned a clock output with clocking switched on or both channels are assigned the same clock output with clocking switched on.
With-out:	Either a clock output with clocking switched off is assigned or no clock output is assigned.

For information about error detection according to clocking, please refer to "Clock outputs UT1 and UT2" on page 2-6.

Error detection

For information about the special features of error detection, please refer to the connection examples.

2.6 Local diagnostic and status indicators

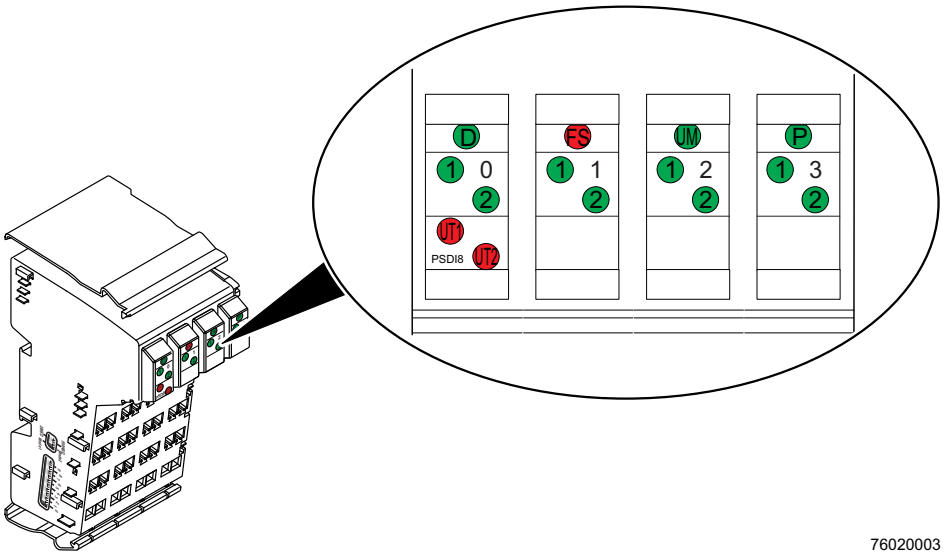

Figure 2-3 Local diagnostic and status indicators on the IC220SDL543 module

Table 2-1 Local diagnostic and status indicators

D	Green LED	Diagnostics
	OFF:	Communications power is not present
	Flashing at 0.5 Hz:	Communications power present, local bus not active
	Flashing at 4 Hz:	Communications power present, error at the interface between previous and flashing terminal (the terminals after the flashing terminal cannot be addressed). (E.g., loose contact at the bus interface, terminal before the flashing terminal has failed, another terminal was snapped on during operation (not permitted))
		Observe the module startup time of approximately 16 s. During this time the D LED flashes at 4 Hz and the bus cannot be started up.
	ON:	Communications power present, local bus active
FS	Red LED	Failure state
	Flashing at 1 Hz:	Device not parameterized or parameterization was not accepted
	ON:	Hardware fault; communication to safe controller (PROFIsafe) or configurable safety module (VersaSafe) disabled
UM	Green LED	Monitoring the supply voltage U_M
	OFF:	Communications power is not present
	Flashing at 1 Hz:	U_M below the permissible voltage range (undervoltage)
	ON:	U_M present
P	Green LED	Status indicator for safe communication
	OFF:	No safe communication
	Flashing at 0.5 Hz:	Safe communication running, the controller requests operator acknowledgment
	ON:	Safe communication running without errors
UT1, UT2	Red LED	Diagnostic message (error) for each clock output
	OFF:	No error
	Flashing at 1 Hz:	Cross circuit of an input with external signals
	ON:	Short circuit or overload of the clock output
		The clock output is switched off until the acknowledgment is received by the safety module (see also "Clock output UT1 and UT2 errors" on page 9-5).
IN 0.1 - 3.2	Green LED	Status of each input (see "Terminal point assignment" on page 3-3)
	ON:	Input at logic 1
	OFF:	Input at logic 0
		Even when the module is not parameterized, the physical state at the inputs is indicated. However, substitute value "0" is transmitted to the safe controller.

2.7 Safe state

The safe state for the module is the transmission of the value equal to "0" in the image of the inputs to the safe controller (PROFIsafe) or the configurable safety module (VersaSafe).

PROFIsafe:

The safe state for the F-Input data is "0".

The safe state is entered by means of passivation (see "iParameter" on page A-2).

The safe state can be entered in the following cases:

1. Operating state
2. Error detection in I/O devices
3. Device errors
4. Parameterization errors

2.7.1 Operating state

In the operating state, the inputs can enter states "1" or "0". In general, state "0" is the safe state. An exception is a non-equivalent parameterized input. For channel 2 of this input, "1" is the safe state, "0" is represented in the process data image of the two-channel input.

Table 2-2 Operating state depending on the state of the inputs

Type of input	Operating state equals 1 in input state	Operating state equals 0 (safe state)
Single-channel	High (1)	Low (0)
Two-channel equivalent	High/High (1/1)	Other
Two-channel non-equivalent	High/Low (1/0)	Other

Please observe the state transitions (see "Symmetry/ start inhibit" on page 5-5).

2.7.2 Error detection in I/O devices

Inputs

If an error is detected at an input, the safe state is set at this input and a "0" is represented in the process image of the input ("0" = safe state).

Depending on the parameterization, the following errors can be detected at inputs:

– Short circuit
– Cross circuit
– Overload/short circuit of the clock outputs

The relevant diagnostic message is transmitted to the safe controller (PROFIsafe) or the configurable safety module (VersaSafe) (see "Safe digital input errors" on page 9-3). For information about which errors are detected and when, please refer to "Connection examples for safe inputs" on page 7-1.

2.7.3 Device errors

Device errors can lead to safe communication being set.

Inputs

If a hardware fault in the internal circuit is detected at an input, **all** module inputs enter the safe state and "0" values are represented in the process image of the inputs ("0" = safe state).

The relevant diagnostic message is transmitted to the safe controller (PROFIsafe) or the configurable safety module (VersaSafe) (see "Safe digital input errors" on page 9-3).

Serious errors

All serious errors that can result in the loss of or adversely affect the safety function cause the entire module to enter the safe state. The FS LED on the safety module is permanently on.

The following errors result in the safe state:

– Serious hardware fault in the internal circuit
– User error
– Module overload
– Overheating of the module
– Incorrect supply

The relevant diagnostic message is transmitted to the safe controller (PROFIsafe) or the configurable safety module (VersaSafe) (see "Errors: Messages and removal" on page 9-1).

WARNING: Loss of the safety function due to sequential errors
In the event of a device error, the following measures should be taken to prevent sequential errors:
Disconnect the module from the power supply and replace it.

2.7.4 Parameterization errors

Parameterization errors are indicated:

– As long as the module is not parameterized

or

– In the event of faulty parameterization

Parameterization errors cause the entire module to enter the safe state. The FS LED on the safety module flashes.

In the event of faulty parameterization, the relevant diagnostic message is transmitted to the safe controller (PROFIsafe) or the configurable safety module (VersaSafe) (see "Parameterization errors" on page 9-6).

2.8 Process data words

2.8.1 VersaSafe

The module occupies four words in the VersaPoint system. For information about how these words are mapped, please refer to the documentation for the configurable safety module used.

The input data can only be accessed via the standard control system.

In the following tables, both the maximum single-channel and maximum two-channel assignment are illustrated. Depending on the parameterization, other process data word assignments are also possible.

Assignment of inputs to the process data input word in the standard control system

(Word.bit) view	Word	Word 1															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(Byte.bit) view	Byte	Byte 2								Byte 3							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Module	Input (single-channel)	IN3_Ch2	IN3_Ch1	IN2_Ch2	IN2_Ch1	IN1_Ch2	IN1_Ch1	IN0_Ch2	IN0_Ch1	Reserved							
	Input (two-channel)	0	IN3_Ch 1&2	0	IN2_Ch 1&2	0	IN1_Ch 1&2	0	IN0_Ch 1&2								

The diagnostic data is transmitted to the standard control system via the configurable safety module.

2.8.2 PROFIsafe (PROFIBUS, PROFINET)

The module occupies four words in the VersaPoint system and three words in the PROFIBUS system. The way in which these words are mapped in the higher-level control system is specific to the controller used and is described in the Quick Start Guide for the controller.

2.9 Programming data/configuration data

2.9.1 Local bus

Protocol	VersaSafe	PROFIsafe
Protocol/address switch	9_{hex} .... FF_{hex} determined by the configurable safety module	Any, 1_{hex} .... $3FE_{hex}$
Operating mode	Mode 2	Mode 1
ID code	$A3_{hex}$ (163_{dec})	CB_{hex} (203_{dec})
Length code	04_{hex} (04_{dec})	04_{hex} (04_{dec})
Input address area	Controller-specific	Controller-specific
Output address area	Controller-specific	Controller-specific
Parameter channel (PCP)	0 words	1 word
Register length	4 words	4 words

– The PCP channel is only used internally.
– The switch position of the protocol/address switch is specified by the configurable safety module (see documentation for the configurable safety module).

2.9.2 Other bus systems (PROFIBUS, PROFINET, etc.)

For the programming data/configuration data of other bus systems, please refer to the corresponding electronic device data sheet (GSD, EDS).

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3 VersaPoint potential and data routing, and VersaPoint connectors

3.1 VersaPoint potential and data routing

In order to operate the safety module it must be integrated in a VersaPoint station within the VersaSafe or PROFIsafe system.

The bus signals are transmitted via the VersaPoint data jumpers. The required supply voltages are transmitted via the VersaPoint potential jumpers.

For more detailed information about potential and data routing within a VersaPoint station, please refer to the GFK-2736 user manual.

The segment circuit is looped through the safety module and is available again after the module. The segment circuit cannot be accessed in the safety module.

3.2 Supply voltage U_L

Supply the 24 V supply voltage U_{BK}/U_{24V} at a bus coupler or a suitable power terminal. The 7.5 V voltage U_L is generated from this 24 V supply voltage in the bus coupler or power terminal. It is supplied to the safety module via the VersaPoint potential jumper U_L.

WARNING: Loss of the safety function when using unsuitable power supplies

Please note for the voltage supply at the bus coupler or power terminal that:
Only power supplies according to EN 50178/VDE 0160 (PELV) may be used.
Make sure that the output voltage of the power supply does not exceed 32 V even in the event of an error.
Please also observe the points in Section "Electrical safety" on page 1-3.

The supply voltage **U_L** is used to supply the communications power. For the technical data for supply voltage U_L, please refer to "Supply voltage UL (logic)" on page 11-3.

The maximum current carrying capacity for the supply voltage U_L is 2 A.
This current carrying capacity can be reduced if certain terminals are used. Please refer to the information in the terminal-specific data sheets.

3.3 Supply voltage U_M

Supply the supply voltage at a bus coupler or a power terminal. It is supplied to the safety module via the VersaPoint potential jumper U_M.

WARNING: Loss of the safety function when using unsuitable power supplies
Please observe the points in Section "Electrical safety" on page 1-3.

The supply voltage **U_M** is used to supply the input circuits and the clock outputs. For the technical data for supply voltage U_M, please refer to Section "Supply voltage UM (sensors, clock outputs)" on page 11-4.

The maximum current carrying capacity for the main circuit U_M is 8 A (total current with the segment circuit that is not used in the safety terminal). This current carrying capacity can be reduced if certain terminals are used. Please refer to the information in the terminal-specific data sheets.

If the limit value of the potential jumpers U_M and U_S is reached (total current of U_S and U_M), a new power terminal must be used.

NOTE: Module damage due to polarity reversal
Polarity reversal places a burden on the electronics and, despite protection against polarity reversal, can damage the module. Therefore, polarity reversal must be prevented.

For the behavior of the safety module in the event of an error at the supply voltage U_M, please refer to Section "Supply voltage errors" on page 9-5.

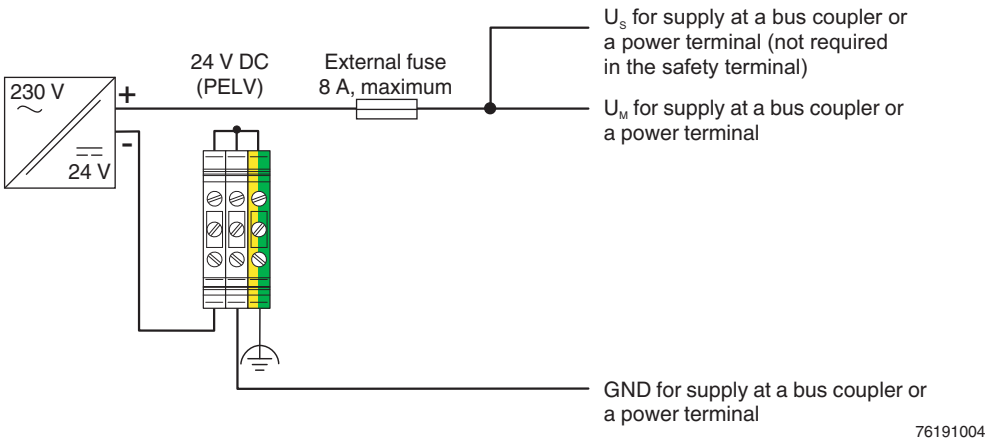

Figure 3-1 Supply U_M with connection to functional earth ground according to EN 60204-1

NOTE: Damage to module electronics in the event of surge voltage
Do not use a DC distribution network.

DC distribution network according to IEC 61326-3-1:
A DC distribution network is a DC power supply network, which supplies a complete industrial hall with DC voltage and to which any device can be connected. A typical system or machine distribution is not a DC distribution network. For devices that are provided for a typical system or machine distribution, the DC connections are viewed and tested as I/O signals according to IEC 61326-3-1.

3.4 Terminal point assignment

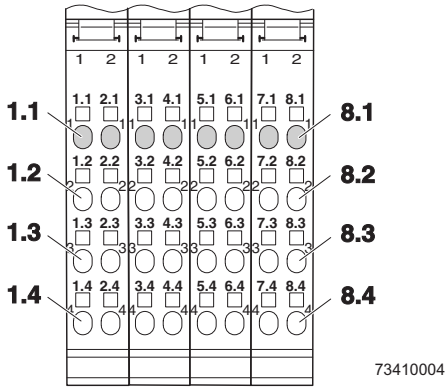

Figure 3-2 Terminal point assignment

The VersaPoint connectors are supplied with the module. They are keyed and labeled accordingly for connection to prevent polarity reversal.

Only use the connectors supplied with the module.

The following applies for the tables below:

- All inputs are safe digital inputs
  The assignment to the clock output must be parameterized (see "Parameterization of the safe inputs" on page 5-3)
- 0 V (GND): Common ground of inputs and clock outputs
- FE: Common functional earth ground
- UT1: Controlled by first channel
- UT2: Controlled by second channel

Table 3-1 Terminal point assignment for connector 1

Terminal point	Signal	Channel assignment	LED
1.1	IN0_Ch1	Input 0, channel 1	0.1
2.1	IN0_Ch2	Input 0, channel 2	0.2
1.2	UT1	Clock output 1	UT1
2.2	UT2	Clock output 2	UT2
1.3	0 V (GND)	Channel 1 and channel 2	
2.3	0 V (GND)	Channel 1 and channel 2	
1.4	FE		
2.4	FE		

Table 3-2 Terminal point assignment for connector 2

Terminal point	Signal	Channel assignment	LED
3.1	IN1_Ch1	Input 1, channel 1	1.1
4.1	IN1_Ch2	Input 1, channel 2	1.2
3.2	UT1	Clock output 1	
4.2	UT2	Clock output 2	
3.3	0 V (GND)	Channel 1 and channel 2	
4.3	0 V (GND)	Channel 1 and channel 2	
3.4	FE		
4.4	FE		

Table 3-3 Terminal point assignment for connector 3

Terminal point	Signal	Channel assignment	LED
5.1	IN2_Ch1	Input 2, channel 1	2.1
6.1	IN2_Ch2	Input 2, channel 2	2.2
5.2	UT1	Clock output 1	
6.2	UT2	Clock output 2	
5.3	0 V (GND)	Channel 1 and channel 2	
6.3	0 V (GND)	Channel 1 and channel 2	
5.4	FE		
6.4	FE		

Table 3-4 Terminal point assignment for connector 4

Terminal point	Signal	Channel assignment	LED
7.1	IN3_Ch1	Input 3, channel 1	3.1
8.1	IN3_Ch2	Input 3, channel 2	3.2
7.2	UT1	Clock output 1	
8.2	UT2	Clock output 2	
7.3	0 V (GND)	Channel 1 and channel 2	
8.3	0 V (GND)	Channel 1 and channel 2	
7.4	FE		
8.4	FE		

WARNING: Loss of functional safety due to parasitic voltages
For sensors that require a GND, this must be wired to 0 V (GND) on the module.

4 Assembly, removal, and electrical installation

4.1 Assembly and removal

4.1.1 Unpacking the module

The module is supplied in an ESD box together with a package slip with installation instructions. Please read the complete package slip carefully.
The module may only be installed and removed by qualified personnel.

NOTE: Electrostatic discharge

The safety module contains components that can be damaged or destroyed by electrostatic discharge. When handling the safety module, observe the necessary safety precautions against electrostatic discharge (ESD) according to EN 61340-5-1 and EN 61340-5-2.

4.1.2 General

WARNING: Unintentional machine startup

Do not assemble or remove the module while the power is connected.

Before assembling or removing the module, disconnect the power to the module and the entire VersaPoint station and ensure that it cannot be switched on again.

Make sure the entire station is reassembled before switching the power back on. Observe the diagnostic indicators and any diagnostic messages.

The system may only be started provided neither the station nor the system poses a hazard.

The IC220SDL543 safety terminal is designed for use within a VersaPoint station. Only use the safety terminal in the 24 V DC area of a VersaPoint station.

To ensure reliable operation, install the safety terminal in housing protected from dust and humidity (IP54 or higher). In order to prevent manipulation, secure the housing (control cabinet/control box) against being opened by unauthorized persons.

Mount all VersaPoint terminals on 35 mm DIN rails.

Only connect the cables using the supplied VersaPoint connectors or VersaPoint connectors listed in the ordering data.

4.1.3 Setting the DIP switches

The module has a 2-pos. and a 10-pos. DIP switch.

The DIP switches are located on the left-hand side of the safety module.

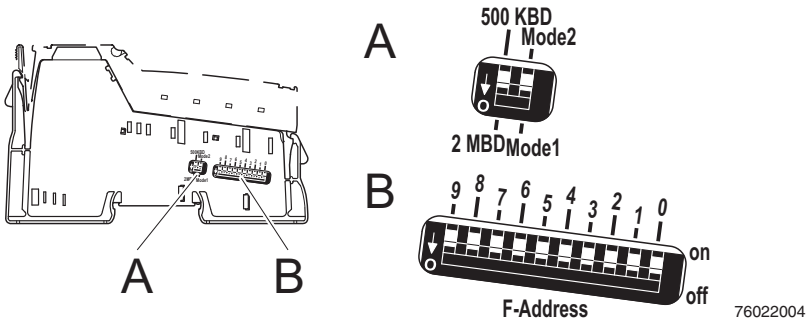

Figure 4-1 DIP switches

A Switch for setting the transmission speed and the operating mode

B Switch for setting the protocol or the address (for PROFIsafe, VersaSafe)

2-pos. DIP switch:

The transmission speed and the operating mode (Mode) are set via the 2-pos. DIP switch.

Left switch: Transmission speed

The transmission speed can be set to 500 kbaud or 2 Mbaud.
The transmission speed is set to 2 Mbaud by default.

Only use devices with a uniform transmission speed within a VersaPoint station (a local bus). A mixture of devices with different transmission speeds cannot be operated.

Right switch: Mode

For PROFIsafe, set Mode 1.

For VersaSafe, set Mode 2.

10-pos. DIP switch: Protocol/address switch

The protocol (VersaSafe or PROFIsafe) is set via the 10-pos. DIP switch. If you are using VersaSafe or PROFIsafe, use this DIP switch to set the VersaSafe address or the PROFIsafe address (F-Address).

VersaSafe: Set the VersaSafe address specified by the configurable safety module.

For more detailed information about the VersaSafe address, please refer to the documentation for the configurable safety module used.

PROFIsafe: Set the PROFIsafe address for the PROFIsafe device. PROFIsafe addresses 1 to 1022 (1_{hex} to $3FE_{hex}$) are permitted. The terminal is detected as a PROFIsafe device by means of the set PROFIsafe address.

The DIP switch is set to $3FF_{hex}$ by default. This address is not valid for a VersaSafe or PROFIsafe system, therefore a valid address must be set.

Overview of the switch positions

Table 4-1 Switch position for VersaSafe

VersaSafe										
Mode switch	**Address switch**									
			Island number					Satellite number		
	9	8	7	6	5	4	3	2	1	0
Mode 2	off	off								
			1_{dec} to 31_{dec}					1_{dec} to 5_{dec}		

Table 4-2 Switch position for VersaSafe in multiplexer mode

VersaSafe multiplexer mode										
Mode switch	**Address switch**									
			Island number					Satellite number		
	9	8	7	6	5	4	3	2	1	0
Mode 2	off	off						on	on	on
			1_{dec} to 31_{dec}					7_{dec}		

Table 4-3 Switch position for PROFIsafe

PROFIsafe										
Mode switch	**Address switch**									
	9	8	7	6	5	4	3	2	1	0
Mode 1										
	1_{hex} to $3FE_{hex}$									

Procedure

If the DIP switch settings have to be modified, proceed as follows:

- Use the switch to set the transmission speed to 500 kbaud or 2 Mbaud.
- Set the address.

Set the DIP switches **before** assembling the module in the VersaPoint station. The switches cannot be accessed when the safety terminal is installed in the VersaPoint station.

4.1.4 Assembly and removal of the safety module

For general information about mounting and removing VersaPoint terminals, please refer to the GFK-2736 user manual.

Assembly

– Set the DIP switches prior to assembly (see "Setting the DIP switches" on page 4-2). The DIP switches cannot be accessed when the safety module is installed in the VersaPoint station.
– Observe a mounting distance of 30 mm above and 40 mm below the safety module. Shorter distances may inhibit proper handling during installation.

- Disconnect the power to the station.

– Snap on base

- Before snapping on the safety module, remove the inserted connectors from the safety terminal and the adjacent connector from the neighboring VersaPoint terminal on the left. This prevents the potential routing knife contacts and the keyway/featherkey connections from being damaged.
- Hold the safety module perpendicular and snap it onto the DIN rail (7.5 mm in height).

Ensure that **all** featherkeys and keyways on adjacent terminals are **securely** interlocked.

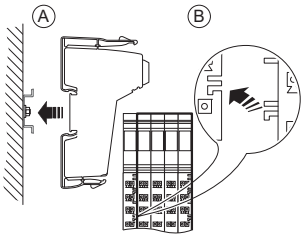

Figure 4-2 Snapping on the safety module base

- Check that all the snap-on mechanisms are securely snapped into place.

– Insert connectors

- Insert the connectors in the specified order (A, B).

Only use the connectors supplied with the module.

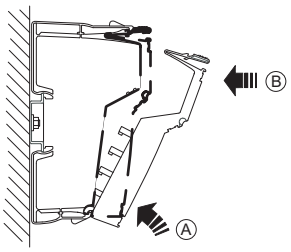

Figure 4-3 Inserting the connector

Removal

- Disconnect the power to the station.
- **R**emove the connectors from the safety module and the adjacent connector from the neighboring VersaPoint terminal on the left.

– Remove connectors

- Remove the connector by pressing the back shaft latching (A) and levering off the connector (B).

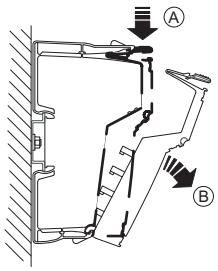

Figure 4-4 Removing the connector

– Remove base

- Release the base by pressing on the front and back snap-on mechanisms (A) and pull it out perpendicular to the DIN rail (B).

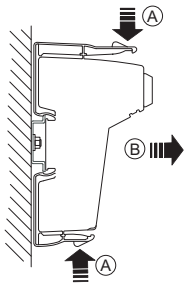

Figure 4-5 Removing the safety module base

4.2 Electrical installation

WARNING: Electric shock/unintentional machine startup

Prior to electrical installation, disconnect the power to the system and make sure that it cannot be switched on again unintentionally.

Make sure installation has been completed before switching the power back on.

The system may only be started provided the system does not pose a hazard.

4.2.1 Electrical installation of the VersaPoint station

Electrical installation of the VersaPoint station includes the following:

– Connecting the bus system to the VersaPoint station
– Connecting the supply voltages for the VersaPoint station

Carry out electrical installation for the VersaPoint station according to the GFK-2736 user manual. Please also observe the specifications in the documentation for the bus coupler used.

4.2.2 Electrical installation of the safety module

During installation, always observe the instructions in "Electrical safety" on page 1-3.

Take measures to prevent the incorrect connection, polarity reversal, and manipulation of connections.

The supply voltages are supplied at a bus coupler and/or a power terminal and are supplied to the safety module via the potential jumpers. Therefore the electrical installation of the safety module only involves connecting the sensors.

The sensors are connected via VersaPoint connectors.

- Wire the connectors according to your application. For the terminal point assignment, please refer to "Terminal point assignment" on page 3-3.

For wiring, proceed as follows:

- Strip 8 mm off the cable.

VersaPoint wiring is normally done without ferrules. However, it is possible to use ferrules. If using ferrules, make sure they are properly crimped.

- Push a screwdriver into the slot of the appropriate terminal point (Figure 4-6, detail 1), so that you can insert the wire into the spring opening.
  GE Intelligent Platforms recommends using a SZF 1 - 0,6X3,5 screwdriver
- Insert the wire (Figure 4-6, detail 2). Remove the screwdriver from the opening. This clamps the wire.

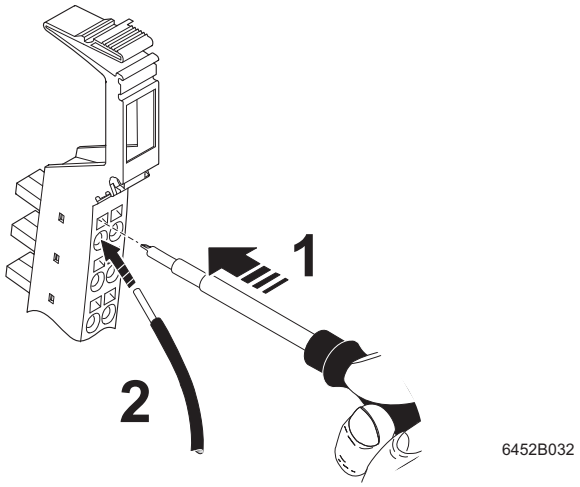

Figure 4-6 Connecting unshielded cables

- Insert the assembled connectors in the corresponding module slot (see "Terminal point assignment" on page 3-3).
- Label all connections to prevent connections to the VersaPoint connectors being mixed up (see GFK-2736 user manual).

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5 Parameterization of the safety module

5.1 Parameterization in a VersaSafe system

Parameterization includes the following:

– Specifying the VersaSafe address for the corresponding configurable safety module
– Parameterizing the inputs and clock outputs

VersaSafe address

The VersaSafe address is a unique ID for the safety module in the VersaSafe structure. It is assigned in the configuration software for the assigned configurable safety module.

The address of the connected satellites (here: IC220SDL543) is based on the island number of the configurable safety module and the position in the bus navigator of the software tool.

Set this address via the DIP switches prior to assembly (see "Setting the DIP switches" on page 4-2).

For more detailed information about the VersaSafe address, please refer to the documentation for the configurable safety module used.

Parameterization of the inputs and clock outputs

The parameterization of the safe inputs and clock outputs determines the behavior of the module and thus has a considerable effect on the safety integrity level that can be achieved.

To parameterize the module, the parameterization of the configurable safety module created in the parameterization tool is automatically written to the module on every power up or reset. The supply voltage must be present and the local bus must be in the RUN state.

The module cannot be operated if it is not parameterized.
In this case, the FS LED flashes.

The module is ready to operate if the parameters for all inputs and clock outputs are valid and transmitted without errors. Valid input data is only read in this state. In every other state, the safe state is transmitted for each input ("0" in the process image of the inputs).

If errors are detected during parameterization, the parameterization data is not transmitted. The invalidity of the parameterization is indicated on the module by the flashing FS LED. In addition, errors are indicated at the configurable safety module. In this case, check and correct the settings.

5.2 Parameterization in a PROFIsafe system

Parameterization includes the following:

– Assigning the PROFIsafe address via the configuration software of the control system manufacturer
– Parameterizing the inputs and clock outputs
– Assigning the parameterizable F-Parameters and iParameters

PROFIsafe address

The PROFIsafe address is a unique ID for the safety module in the PROFIsafe structure. It is assigned in the configuration software. Set this address via the DIP switches prior to assembly (see "Setting the DIP switches" on page 4-2).

Parameterization of the inputs and clock outputs

The parameterization of the safe inputs and clock outputs determines the behavior of the module and thus has a considerable effect on the safety integrity level that can be achieved.

To parameterize the module, the parameterization of the safe controller created in the parameterization tool is automatically written to the module on every power up or reset.

The following conditions must be met:

– The supply voltage is present.
– The local bus is in the RUN state.
– The communication connection has been established between the controller and safety module.

The module cannot be operated if it is not parameterized.
In this case, the FS LED flashes.

The module is ready to operate if the parameters for all inputs and clock outputs are valid and transmitted without errors. Valid input data is only read in this state. In every other state, the safe state is transmitted for each input ("0" in the process image of the inputs).

If errors are detected during parameterization, the parameterization data is not transmitted. The invalidity of the parameterization is indicated on the module by the flashing FS LED. In addition, errors are indicated at the safe controller. In this case, check and correct the settings. For information about error messages and instructions for their removal, please refer to "Errors: Messages and removal" on page 9-1.

F-Parameters and iParameters

Assign the parameterizable F-Parameters and iParameters. For an overview of the module parameters and possible settings, please refer to "Appendix: F-Parameters and iParameters" on page B-1.

5.3 Parameterization of the safe inputs

The individual inputs of a safety module can be parameterized differently and thus achieve different safety integrity levels (SIL, SIL CL, Cat., PL).

Two-channel

If the inputs are operated via two channels, the following fixed assignment applies:

– IN0_Ch1 to IN0_Ch2
– IN1_Ch1 to IN1_Ch2
– IN2_Ch1 to IN2_Ch2
– IN3_Ch1 to IN3_Ch2

Single-channel

If two-channel operation in the external wiring of the inputs is not required, the inputs can be parameterized in such a way that they operate independently of one another (single-channel).

Position of the data in the process data word

(Word.bit) view	Word	Word 0															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(Byte.bit) view	Byte	Byte 0								Byte 1							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Module	Input (single-channel)	IN3 _Ch2	IN3 _Ch1	IN2 _Ch2	IN2 _Ch1	IN1 _Ch2	IN1 _Ch1	IN0 _Ch2	IN0 _Ch1	Reserved							
	Input (two-channel)	0	IN3 _Ch 1&2	0	IN2 _Ch 1&2	0	IN1 _Ch 1&2	0	IN0 _Ch 1&2								

Clock outputs

Please observe the settings of clock outputs UT1 and UT2 when parameterizing the safe inputs.

If the safe inputs are assigned the same or no clock output, cross-circuit detection is not possible.

Parameterization Parameterize all safe inputs individually. The parameterization options are described in Table 5-1.

Table 5-1 Parameterization of inputs

Parameterization	Value range	Remark
Assignment	Not used Used	For unused inputs, the data is filled with 0.
Evaluation	Single-channel Two-channel	For "two-channel": The assignment of the inputs to one another is specified and cannot be parameterized.
Sensor type	Standard sensor Intelligent sensor	If intelligent sensors are used, the clock outputs for "standard sensor" mode are no longer available. In this case, all inputs that are operated with standard sensors are operated without clock outputs. Select the clock output setting "no assignment" for these inputs. Please note that error diagnostics for I/O devices are only limited in this operating mode.
Filter time (t_{Filter})	1.5 ms 3 ms 5 ms 15 ms	The filter time is used to suppress interference for the input signals. Select the filter time so that the duration of the input signal is greater than the filter time. For inputs that are parameterized for two-channel operation, select the same filter time for both channels.
	The filter time directly affects the response time of the safety function.	
Symmetry	Disabled 10 ms 50 ms 100 ms 1 s 5 s	Parameterization is only active if the input is parameterized for two-channel operation. Select the same value for both channels. See also "Symmetry/ start inhibit" on page 5-5.
Start inhibit due to symmetry violation	Disabled Enabled	Disabled (default setting): A diagnostic message is generated in the event of symmetry violation. Enabled: A diagnostic message is generated in the event of symmetry violation. In addition, the affected input is set to the safe state.

Table 5-1 Parameterization of inputs [...]

Parameterization	Value range	Remark
Clock selection (in software: pulse selection)	No assignment UT1 UT2	Assignment of the input to a clock output. Only relevant for standard sensors. When using intelligent sensors, UT1 is used as the power supply and UT2 as the pulse generator for all inputs.
Bouncing time monitoring (in software: bounce time monitoring)	Disabled Enabled	Monitoring of the activation and deactivation of the bouncing time. See also "Bouncing time monitoring (bounce time monitoring)" on page 5-5.
Input signal	Non-equivalent Equivalent	Parameterization is only active if the input is parameterized for two-channel operation. Select the same setting for both channels. Non-equivalent: Connect N/C contact to INx_Ch1 Connect N/O contact to INx_Ch2 Equivalent: Connect N/C contact to both channels

Bouncing time monitoring (bounce time monitoring)

Input signal bouncing can lead to delayed state transitions. If a detected state transition is 200% longer than the parameterized filter time, a corresponding diagnostic message is sent. The exception is a filter time of 15 ms. For this filter time, the duration of the state transition can be increased by a maximum of 100%.

Symmetry/ start inhibit

Symmetry monitoring can be used to monitor the contact wear of the switch. Symmetry monitoring checks the extent to which the related (filtered) inputs enter another state simultaneously. Symmetry is violated if the inputs indicate different states for a time greater than the value parameterized for "symmetry". This applies for positive and negative edges.

The safe controller (PROFIsafe) or the configurable safety module (VersaSafe) is informed of a symmetry violation by a diagnostic message. If "start inhibit due to symmetry violation" is enabled, symmetry violation means that the affected input enters the safe state.

Key for the following diagrams:

S	Symmetry monitoring
Diag	Diagnostics
Q	Acknowledgment of the diagnostic message; after acknowledging the diagnostic message, the current state is read.

For non-equivalent parameterization, a negated signal is present at input IN0_Ch2 shown in the diagrams.

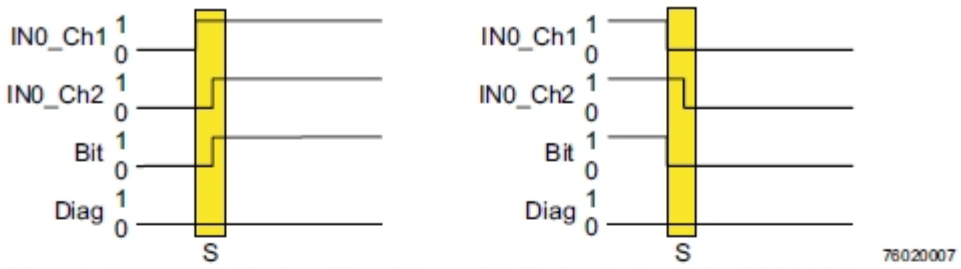

Figure 5-1 Example for a signal change within the parameterized time for symmetry monitoring

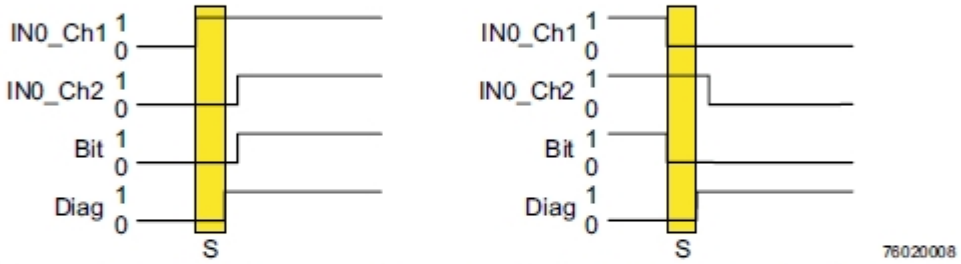

Figure 5-2 Example for a signal change outside the parameterized time for symmetry monitoring; start inhibit due to symmetry violation is disabled

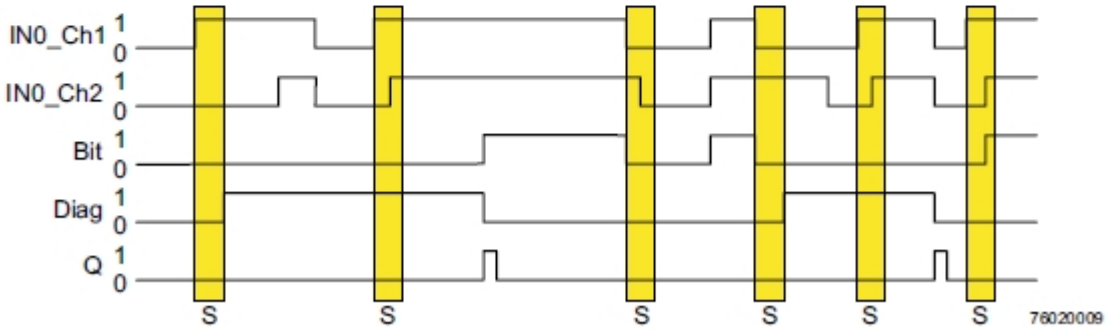

Figure 5-3 Example for a signal change outside the parameterized time for symmetry monitoring; start inhibit due to symmetry violation is enabled

After acknowledging the diagnostic message (see "Acknowledging an error" on page 9-9), the current state at the input is immediately transmitted to the safe controller (PROFIsafe) or the configurable safety module (VersaSafe). If a startup inhibit is required following error acknowledgment, this must be implemented by the user in the application program.

A symmetry violation can also be triggered by a cross circuit (see "Connection examples for safe inputs" on page 7-1).

Processing time of the input t_{IN} in the event of a safety demand

The processing time of the input t_{IN} in the event of a safety demand comprises the parameterized filter time t_{Filter} and the firmware runtime t_{FW}. It is calculated for the IC220SDL543 module according to the following formula:

$$t_{IN} = t_{Filter} + t_{FW}$$

Where:

t_{IN} Processing time of the input

t_{Filter} Parameterized filter time

t_{FW} Firmware runtime:

- For standard sensors: 250 µs
- For intelligent sensors:
  For additional information, please refer to the data sheet for the GE Intelligent Platforms intelligent sensor used.

5.4 Parameterization of clock outputs UT1 and UT2

As long as the module is not parameterized:

- The clock outputs are enabled if no errors are present.
- Short circuit detection is activated.

Select the parameterization of clock outputs according to Table 5-2.

Table 5-2 Parameterization of clock outputs

Values	Remark
UT1 ON/UT2 ON	Clocking for UT1 and UT2 enabled
UT1 ON/UT2 OFF	Clocking for UT1 enabled Clocking for UT2 disabled (constant 24 V)
UT1 OFF/UT2 ON	Clocking for UT1 disabled (constant 24 V) Clocking for UT2 enabled
OFF	Clocking for UT1 and UT2 disabled (constant 24 V)
Manufacturer and sensor designation	Setting for intelligent sensors; for additional information, see separate documentation for intelligent sensors

If clock outputs are parameterized without clock pulses, no cross circuits or short circuits can be detected between the channels.

If clocking is enabled, the clock output is operated with a maximum pulse width of 1 ms and a maximum period length of 80 ms.
The time offset between the clocks of the clock outputs is approximately 50% of the period length.

If both channels of a two-channel input are assigned the same clock output, cross-circuit detection has no effect.

Typical pulse pattern for parameterization UT1 ON and UT2 ON

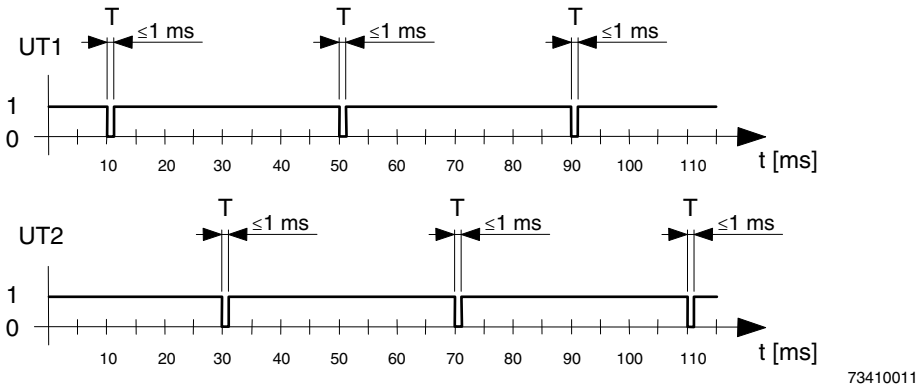

Figure 5-4 Typical pulse pattern (standard sensor)

Key:

T	Test pulse
	Pulse width ≤ 1 ms
	Period length ≤ 80 ms

6 Duration of a safety demand

The duration of a safety demand must be greater than the processing time of the corresponding input (t_{IN}, see also "Processing time of the input t_{IN} in the event of a safety demand" on page 5-7).

6.1 VersaSafe

If the safety module detects a safety demand after the processing time of the input t_{IN} has elapsed, when using VersaSafe this time is extended by the module until the configurable safety module has received the safety demand.

6.2 PROFIsafe

If the safety module detects a safety demand (safe "0") after the processing time of the input t_{IN} has elapsed, when using PROFIsafe this time is extended by the module until the consecutive number has changed twice.

WARNING: Loss of functional safety

Observe the behavior of the controller when processing the safe inputs.

In addition to the processing time of the input t_{IN}, please observe the system-specific PROFIsafe behavior (e.g., watchdog time, duration of demand, processing time of the safe controller).

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7 Connection examples for safe inputs

7.1 Explanation of the examples

Depending on the type of wiring, the inputs of a module can achieve different safety integrity levels (SIL, SIL CL, Cat., PL) at the same time (as long as the settings do not contradict one another).

The following examples only describe the options for the electrical connection of sensors to the safe inputs.
Should you have any questions regarding applications to be implemented, please contact the GE Intelligent Platforms.

The following are specified for each example:

– **Basic specifications**
  The main data for the example is specified in the table.
– **Device diagnostics and behavior of the module in the event of an error**
  Diagnostic capability depends on the parameterization.
  If a message is transmitted to the safe controller (PROFIsafe) or the configurable safety module (VersaSafe) in the event of an error, the message is specified in the tables. For information about the relevant error code, possible remedies, and information about whether acknowledgment is required, please refer to "Errors: Messages and removal" on page 9-1.
  The symmetry violation diagnostic message is only displayed if it was not disabled during parameterization of the affected input.
– **Typical parameterization**
  The table illustrates an example of all the parameters for the specified assignment.

Key for all figures and tables in this section:

Table 7-1 Figures

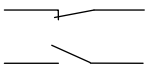
Representation	Meaning
 73410009	Floating switch (mechanical or electrical)

Table 7-2 "Device diagnostics and behavior of the module in the event of an error" tables

Representation	Meaning
SF	Safety function
UTx	UT1 or UT2 LED; diagnostic message for each clock output
Clocked	Clocking enabled

Table 7-3 Parameterization tables

Representation	Meaning
Bold	Mandatory setting
Normal	Typical setting, another setting is possible depending on the application
–	Not evaluated

Errors (cross circuits, short circuits), which can be prevented by correct installation (e.g., protected cable installation, isolated cable installation, double insulation, use of ferrules) are not described in the following tables.
Therefore, for example, only errors between inputs, which are on the same connector, are described. For example, in the event of correct installation, cross circuits with inputs/outputs of other connectors cannot occur.

For all examples, please also observe the measures specified in the individual tables, which must be taken to achieve the specified SIL/SIL CL/Cat./PL and all measures according to standards EN 61508, EN 62061, and EN ISO 13849-1 to achieve the specified SIL/SIL CL/Cat./PL.

The input signals can be supplied externally or by the clock outputs. The clock outputs and the assignment of the input signals to the clock outputs are parameterized as required.

7.2 Measures required to achieve a specific safety integrity level

The safety integrity level (SIL, SIL CL, performance level, and category) that can be achieved is specified for each connection example.

SIL/SIL CL

In order to determine the probability of failure according to EN 61508 (SIL), use the standard.

In order to determine the probability of failure according to EN 62061 (SIL CL), use this standard.

When the SIL/SIL CL is specified, the module takes up 1% of the specified SIL/SIL CL.

Table 7-4 PFD and PFH depending on the SIL/SIL CL

	PFD	PFH
SIL 2/SIL CL 2	1% of 10^{-2}	1% of 10^{-6}
SIL 3/SIL CL 3	1% of 10^{-3}	1% of 10^{-7}

Performance level

Use standard EN ISO 13849-1 to determine the performance level.

Category

In order to actually achieve the specified category, the required measures listed below must be implemented.

Cat. 2

- Use proven and basic safety principles according to EN ISO 13849-2.
- Use appropriately qualified sensors (see "Requirements for controlling devices/sensors" on page 2-5).
- Please note that mechanical failure of the switching device can result in the loss of the safety function.
- Take appropriate measures (e.g., fuse protection, redundancy, positive opening, etc.) to ensure that the contacts can be opened (e.g., following welding or mechanical failure) when a switch is actuated.
- Please note that **a single** error can result in the loss of the safety function between tests.
- Ensure that the external wiring is tested by the machine control system on machine startup and at suitable intervals. This test must detect the loss of the safety function.

Cat. 3

- Use proven and basic safety principles according to EN ISO 13849-2.
- Use appropriately qualified sensors (see "Requirements for controlling devices/sensors" on page 2-5).
- Please note that mechanical failure of the switching device can result in the loss of the safety function.
- Take appropriate measures (e.g., fuse protection, redundancy, positive opening, etc.) to ensure that the contacts can be opened (e.g., following welding or mechanical failure) when a switch is actuated.
- Please take into consideration errors with a common cause.
- All errors that cannot be detected can result in the loss of the safety function. Take appropriate measures to prevent such errors. Suitable measures include, for example, protected cable installation or double insulation. Please note the information in the following tables.
- Ensure that **a single** error does not result in the loss of the safety function.
- If single-channel sensors are not available for this category, use two-channel sensors.

Cat. 4

- Use proven and basic safety principles according to EN ISO 13849-2.
- Use appropriately qualified sensors (see "Requirements for controlling devices/sensors" on page 2-5).
- Please note that mechanical failure of the switching device can result in the loss of the safety function.
- All errors that cannot be detected can result in the loss of the safety function. Take appropriate measures to prevent such errors. Suitable measures include, for example, protected cable installation or double insulation. Please note the information in the following tables.
- An accumulation of errors must not result in the loss of the safety function. Following the third error, evaluation can be aborted if the probability of further errors occurring is low.
- Please take into consideration errors with a common cause.

7.3 Single-channel assignment of safe inputs

For the single-channel assignment of safe inputs, the inputs operate independently of one another. The assignment of each input signal to the clock output can be freely selected.

For the following examples, please note the resulting behavior in the event of an error:

Note about cross circuits

- Please note that cross circuits with other inputs can only be detected if the input signals are assigned to different clock outputs and clocks are enabled for the clock outputs.
- The **cross circuit** error results in the transmission of the safe state in the process data image of the affected inputs.
  Remove the error and then acknowledge the message.
- Please observe the maximum failure detection time of 80 ms.
  If a "1" signal is present at the input and an error occurs, a maximum of 80 ms elapses until the error is detected. Within this time, another "1" can also be transmitted, even in the event of an error.
  Within the failure detection time (80 ms, maximum), the error can cause the state to change unexpectedly from "0" to "1".
  Ensure that such a change in state cannot restart the system unintentionally.

  Please note that the processing time for the input t_{IN} increases by up to 80 ms in the event of an error.

The following supply options are available for single-channel assignment:

1 UT1, clocking enabled
2 UT2, clocking enabled
3 UT1, clocking disabled
4 UT2, clocking disabled
5 External supply (external +24 V or OSSD)

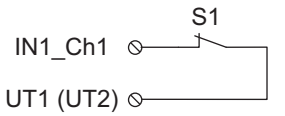
State evaluation

The module evaluates the states of the inputs and transmits the result to the safe controller (PROFIsafe) or the configurable safety module (VersaSafe).

In the process data image of a safe input:

- A "0" is transmitted if a "0" signal is present at the input **or** an error has been detected.
- A "1" is transmitted if a "1" signal is present at the input **and** no error has been detected.

7.3.1 Single-channel: Supply through UT1 (clocking enabled) or UT2 (clocking enabled)



S1 Safety switch

Figure 7-1 Single-channel assignment of the inputs, supply through UT1 (clocked) or UT2 (clocked)

Basic specifications

Sensor	Single-channel
Sensor supply	Internally through clock output UT1 (clocked) or UT2 (clocked)
Achievable SIL/SIL CL/Cat./PL	SIL 2/SIL CL 2/Cat. 3/PL d

WARNING: Loss of electrical and functional safety
- To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
- Please note that in order to achieve the specified PL, the sensor must have a medium level of diagnostic coverage (90% to 99%) and medium MTTFd. A high level of diagnostic coverage (> 99%) is recommended for the application according to PL d.
- Use sensors that can achieve the required safety integrity level.

Device diagnostics and behavior of the module in the event of an error

Table 7-5 Single-channel: Supply through UT1 (clocked) or UT2 (clocked)

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function.
A contact will not close	**No**	None	No	The error cannot be detected.
Other errors (depending on the sensor)				**Please take into consideration possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Input (Cable interrupt between clock output and sensor or between sensor and input)	Yes	None	No	**– Behavior when the input is in state "1":** The error is detected as a change in state from "1" to "0". An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.** **– Behavior when the input is in state "0":** **Please note that if this error causes the safety switch to be switched on again, this can result in delayed transmission of state "1" in the process data image of the inputs (e.g., due to a loose contact).**

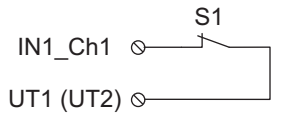
Table 7-5 Single-channel: Supply through UT1 (clocked) or UT2 (clocked) [...]

Error type	Detection	Diagnostics	Loss of SF	Remark
Cross circuit				
Input to input	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is jumpered. If the inputs are assigned different clock outputs, this error is detected as a cross circuit after 80 ms.
Input to assigned clock output	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is jumpered.
Input to non-assigned clock output	Yes	Cross circuit	No	See "Note about cross circuits" on page 7-5.
Clock output to clock output	Yes	Cross circuit	No	The error is only detected in state "1" of the input.
Short circuit				
Input to ground	Yes	None	No	The error is only detected as a change in state from "1" to "0" in state "1" of the input. An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.**
Clock output to ground	Yes	Short circuit UTx ON	No	The affected clock output is disabled.

Typical parameterization

Parameterization	Parameterized as	Remark
Input		
Assignment	**Used**	
Evaluation	**Single-channel**	
Sensor type	**Standard sensor**	
Filter time (t_{Filter})	3 ms	Application-specific
Symmetry	Disabled	Not relevant
Clock selection (pulse selection)	UT1	Or UT2
Bouncing time monitoring (bounce time monitoring)	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Not relevant
Input signal	Equivalent	Not relevant
Clock output		
	UT1 ON (UT2 any)	If clock selection = UT1

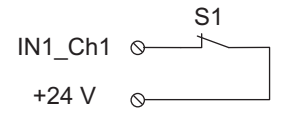
7.3.2 Single-channel: Supply through UT1 (clocking disabled) or UT2 (clocking disabled) or external supply



S1
Safety switch

UT1 (UT2)
Supply through UT1 **or** UT2

Figure 7-2 Single-channel assignment of inputs:
Supply through UT1 or UT2 (clocking disabled for each)



S1
Safety switch

+24 V
Supply through external 24 V

Figure 7-3 Single-channel assignment of inputs: External supply

Basic specifications

Sensor	Single-channel switch
Sensor supply	– Internally through clock output UT1 or UT2; clocking disabled for each – External (24 V)
Achievable SIL/SIL CL/Cat./PL	SIL 2/SIL CL 2/Cat. 2/PL d

WARNING: Loss of electrical and functional safety

- To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
- Please note that in order to achieve the specified PL, cross circuits must be avoided.
- Please note that in order to achieve the specified PL, the sensor must have a medium level of diagnostic coverage (90% to 99%) and high MTTFd. A high level of diagnostic coverage (> 99%) is recommended for the application according to PL d.
- Use sensors that can achieve the required safety integrity level.

Device diagnostics and behavior of the module in the event of an error

Table 7-6 Single-channel: Supply through UT1 (clocking disabled) or UT2 (clocking disabled), external supply or OSSD

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function.
A contact will not close	**No**	None	No	The error cannot be detected.
Other errors (depending on the sensor)				**Please take into consideration possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Input (Cable interrupt between clock output and sensor or between sensor and input)	Yes	None	No	**– Behavior when the input is in state "1":** The error is detected as a change in state from "1" to "0". An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.** **– Behavior when the input is in state "0":** **Please note that if this error causes the safety switch to be switched on again, this can result in delayed transmission of state "1" in the process data image of the inputs (e.g., due to a loose contact).**
Cross circuit				
Input to input; the inputs are assigned different clock outputs	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is jumpered.
Input to input; the inputs are assigned the same clock output	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is jumpered.
Input to assigned clock output	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is jumpered.
Input to non-assigned clock output	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is jumpered.
Clock output to clock output	**No**	None	No	The error cannot be detected as clocking is disabled.
Short circuit				
Input to external 24 V	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is jumpered.
Input to ground	Yes	None	No	The error is only detected as a change in state from "1" to "0" in state "1" of the input. An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.**
Clock output to external 24 V	**No**	None	No	The error cannot be detected as clocking is disabled.
Clock output to ground	Yes	Short circuit UTx ON	No	The affected clock output is disabled.
External 24 V to ground	Yes	None	No	The error is only detected as a change in state from "1" to "0" in state "1" of the input. An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). Ensure that such a change in state cannot restart the system unintentionally.

Typical parameterization

Parameterization	Parameterized as	Remark
Input		
Assignment	**Used**	
Evaluation	**Single-channel**	
Sensor type	**Standard sensor**	
Filter time (t_{Filter})	3 ms	Application-specific
Symmetry	Disabled	Not relevant
Clock selection (pulse selection)	UT1	Or UT2 or no assignment
Bouncing time monitoring (bounce time monitoring)	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Not relevant
Input signal	Equivalent	Not relevant
Clock output		
	UT1 OFF (24 V) (UT2 any)	If clock selection = UT1

7.3.3 Single-channel: Supply through OSSD

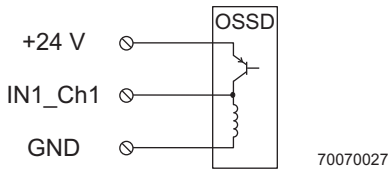


Figure 7-4 Single-channel assignment of inputs: External supply (OSSD)

WARNING: Loss of functional safety due to parasitic voltages
Connect the sensor ground directly to terminal point GND of the safety module. An external ground may not be used.

Basic specifications

Sensor	Single-channel OSSD output (with internal testing)
Sensor supply	External (OSSD sensor)
Achievable SIL/SIL CL/Cat./PL	SIL 2/SIL CL 2/Cat. 2/PL d

WARNING: Loss of electrical and functional safety

- To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
- Please note that in order to achieve the specified PL, cross circuits must be avoided.
- Please note that in order to achieve the specified PL, the sensor must have a medium level of diagnostic coverage (90% to 99%) and high MTTFd. A high level of diagnostic coverage (> 99%) is recommended for the application according to PL d.
- Use sensors that can achieve the required safety integrity level.

Device diagnostics and behavior of the module in the event of an error

Table 7-7 Single-channel: Supply through OSSD

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
(Depends on the sensor)				**Please take into consideration possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Input (Cable interrupt between clock output and sensor or between sensor and input)	Yes	None	No	**– Behavior when the input is in state "1":** The error is detected as a change in state from "1" to "0". An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.** **– Behavior when the input is in state "0":** **Please note that if this error causes the safety switch to be switched on again, this can result in delayed transmission of state "1" in the process data image of the inputs (e.g., due to a loose contact).**
Input (Cable interrupt between sensor and GND)	No	None	No	The error must be detected by the sensor. **The sensor must ensure that the safe state is entered in the event of an error.**
Cross circuit				
Input to input; the inputs are assigned different clock outputs	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is jumpered.
Input to input; the inputs are assigned the same clock output	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is jumpered.
Input to assigned clock output	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is jumpered.
Input to non-assigned clock output	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is jumpered.
Clock output to clock output	**No**	None	No	The error cannot be detected as clocking is disabled.

Table 7-7 Single-channel: Supply through OSSD [...]

Error type	Detection	Diagnostics	Loss of SF	Remark
Short circuit				
Input to external 24 V	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is jumpered.
Input to ground	Yes	None	No	The error is only detected as a change in state from "1" to "0" in state "1" of the input. An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.**
Clock output to external 24 V	**No**	None	No	The error cannot be detected as clocking is disabled.
Clock output to ground	Yes	Short circuit UTx ON	No	The affected clock output is disabled.
External 24 V to ground	Yes	None	No	The error is only detected as a change in state from "1" to "0" in state "1" of the input. An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). Ensure that such a change in state cannot restart the system unintentionally.

Typical parameterization

Parameterization	Parameterized as	Remark
Input		
Assignment	**Used**	
Evaluation	**Single-channel**	
Sensor type	**Standard sensor**	
Filter time (t_{Filter})	3 ms	Application-specific
Symmetry	Disabled	Not relevant
Clock selection (pulse selection)	No assignment	
Bouncing time monitoring (bounce time monitoring)	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Not relevant
Input signal	Equivalent	Not relevant
Clock output		
	UT1 OFF (24 V) (UT2 any)	Not relevant

Set the filter time for the input to a value greater than the width of the test pulse for the OSSD sensor.

The input must not be assigned to a clock.

7.4 Two-channel equivalent assignment of safe inputs

For two-channel assignment of the inputs, two adjacent inputs are always used. This assignment is fixed and cannot be parameterized (see "Two-channel" on page 5-3).

For two-channel equivalent assignment, the state changes from "0" to "1" only when both inputs change state from "0" to "1". If symmetry monitoring is enabled and the state at both inputs does not change within the parameterized time, a diagnostic message is generated.

An input is active when the state of the signal is equal to "1".

Cross circuits between different inputs can only be detected if the input signals are assigned to different clock outputs and clocks are enabled for the clock outputs.

Please note that if a delayed change in state at one of the two inputs causes the safety switch to be switched on again, this can result in delayed transmission of state "1" in the process data image of the inputs (e.g., due to a loose contact).

Example of correct and incorrect signal change

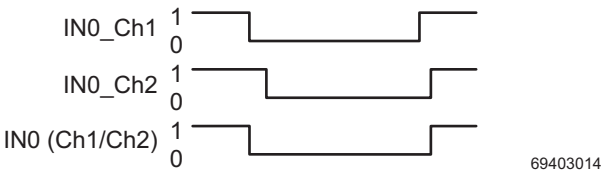


Figure 7-5 **Correct** signal change

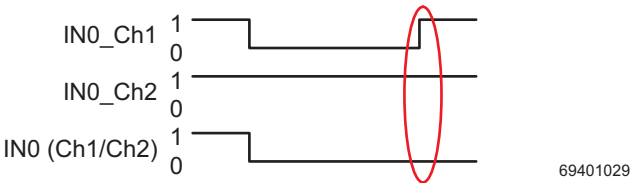


Figure 7-6 **Error** during signal change

In Figure 7-6, the condition that both signals must be in state "0" before the change in state from "0" to "1" is not met. In this case, diagnostic message 018x$_{hex}$ is generated.

Key for Figure 7-5 and Figure 7-6

IN0_Ch1	Signal sequence at input 0 channel 1
IN0_Ch2	Signal sequence at input 0 channel 2
IN0 (Ch1/Ch2)	Safety-related signal for two-channel input 0 channel 1 and channel 2 at the safe controller (PROFIsafe) or the configurable safety module (VersaSafe)

State evaluation

The module evaluates the states of the inputs and transmits the result to the safe controller (PROFIsafe) or the configurable safety module (VersaSafe).

In the process data image of the safe inputs:

– A "0" is transmitted if a "0" signal is present at at least one of the two inputs **or** an error has been detected.
– A "1" is transmitted if a "1" signal is present at both inputs **and** no error has been detected and the conditions are met for a change in state according to Figure 7-6.

7.4.1 Notes about errors for two-channel equivalent assignment of safe inputs

For the following examples, please note the resulting behavior in the event of an error:

Note about cross circuits

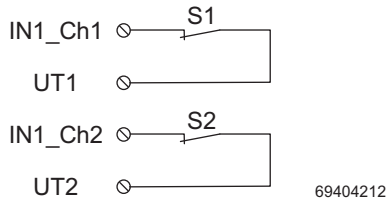
– The **cross circuit** error results in the transmission of the safe state in the process data image of the affected inputs.
  Remove the error and then acknowledge the message.
  Acknowledging the diagnostic message deletes the message and activates the input. The states at the input are detected immediately. **In your safe application program, ensure that the system cannot be restarted unintentionally following acknowledgment of the diagnostic message.**
– Please observe the maximum failure detection time of 80 ms.
  Exceptions in the failure detection time are indicated in the tables.
  If a "1" signal is present at the input and an error occurs, a maximum of 80 ms elapses until the error is detected. Within this time, another "1" can also be transmitted, even in the event of an error.
  Within the failure detection time (80 ms, maximum), the error can cause the state to change unexpectedly from "0" to "1".
  Ensure that such a change in state cannot restart the system unintentionally.

Note about symmetry violation

– The symmetry violation diagnostic message is only displayed if it was not disabled during parameterization of the affected input.
– **Start inhibit due to symmetry violation is disabled:**
  The symmetry violation message does **not** result in the transmission of the safe state (see also "Symmetry/ start inhibit" on page 5-5).
  The message must be acknowledged. However, the current status of the inputs is displayed in the process data image of the inputs.
– **Start inhibit due to symmetry violation is enabled:**
  The symmetry violation message results in the transmission of the safe state (see also "Symmetry/ start inhibit" on page 5-5).
  The message must be acknowledged. The current status of the inputs is displayed in the process data image of the inputs following acknowledgment.
– The message can be used to monitor the wear of the safety switch.

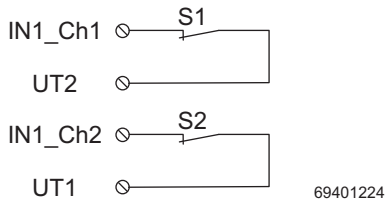
7.4.2 Two-channel equivalent: Supply through UT1 and UT2 (clocking enabled for both)

Possible wiring versions:



S1, S2
Two switching elements

Figure 7-7 Two-channel equivalent assignment of inputs, supply through UT1 and UT2 (both clocked)



S1, S2
Two switching elements

Figure 7-8 Two-channel equivalent assignment of inputs, supply through UT1 and UT2 (both clocked)

Basic specifications

Sensor	Two-channel equivalent
Sensor supply	Internally through clock output UT1 **and** UT2 (both clocked)
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 4/PL e

WARNING: Loss of electrical and functional safety

– To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
– Please note that in order to achieve the specified PL, the sensor must have a high level of diagnostic coverage (> 99%) and high MTTFd.
– Use sensors that can achieve the required safety integrity level.

Device diagnostics and behavior of the module in the event of an error

To understand the change in state, please refer to "Example of correct and incorrect signal change" on page 7-13.

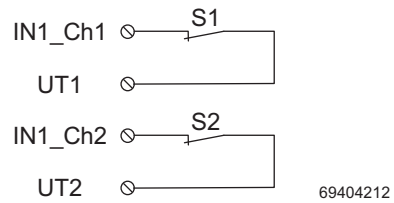
Table 7-8 Two-channel equivalent: Supply through UT1 and UT2 (both clocked)

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. **– Change in state from "0" to "1":** A "0" is transmitted in the process data image of the affected inputs, as the faulty input was not previously set to state "0".
A contact will not close	Yes	Symmetry violation	No	On a change in state from "0" to "1", a "0" is transmitted in the process data image of the affected inputs, as only one channel reports this change in state.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Input (Cable interrupt between clock output and sensor or between sensor and input)	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.
Cross circuit				
Input to input	Yes	Cross circuit	No	The error is detected in state "1".
Input to assigned clock output	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. **– Change in state from "0" to "1":** A "0" is transmitted in the process data image of the inputs, if the faulty input was not previously set to state "0".
Input to non-assigned clock output	Yes	Cross circuit	No	See "Note about cross circuits" on page 7-14.
Clock output to clock output	Yes	Cross circuit	No	The error is detected for inputs, which are assigned to different clock outputs.
Short circuit				
Input to ground	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel. The error is also detected as a short circuit of the clock output. The affected clock output is disabled.

Typical parameterization

Parameterization	Parameterized as		Remark
Input	**Channel 1**	**Channel 2**	
Assignment	**Used**	**Used**	
Evaluation	**Two-channel**	**Two-channel**	
Sensor type	**Standard sensor**	**Standard sensor**	
Filter time (t_{Filter})	3 ms	3 ms	Application-specific, same value
Symmetry	10 ms	10 ms	Application-specific, same value
Clock selection (pulse selection)	UT1	UT2	Or vice versa
Bouncing time monitoring (bounce time monitoring)	Disabled	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Disabled	Application-specific, same for both inputs
Input signal	**Equivalent**	**Equivalent**	
Clock output			
	UT1 ON and UT2 ON		

7.4.3 Two-channel equivalent: Supply through UT1 and UT2 (of which one clock pulse is disabled)



S1, S2
Two switching elements

Figure 7-9 Two-channel equivalent assignment of inputs, supply through UT1 and UT2 (of which one clock pulse is disabled)

Basic specifications

Sensor	Two-channel equivalent
Sensor supply	Internally through clock output UT1 **and** UT2 (of which one clock pulse is disabled)
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 4/PL e

WARNING: Loss of electrical and functional safety
- To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
- Please note that in order to achieve the specified PL, the sensor must have a high level of diagnostic coverage (> 99%) and high MTTFd.
- Use sensors that can achieve the required safety integrity level.

Device diagnostics and behavior of the module in the event of an error

To understand the change in state, please refer to "Example of correct and incorrect signal change" on page 7-13.

Table 7-9 Two-channel equivalent: Supply through UT1 and UT2 (of which one clock pulse is disabled)

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. **– Change in state from "0" to "1":** A "0" is transmitted in the process data image of the affected inputs, as the faulty input was not previously set to state "0".
A contact will not close	Yes	Symmetry violation	No	On a change in state from "0" to "1", a "0" is transmitted in the process data image of the affected inputs, as only one channel reports this change in state.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Input (Cable interrupt between clock output and sensor or between sensor and input)	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.
Cross circuit				
Input to input	Yes	Cross circuit	No	The error is detected in state "1".
Input to assigned clock output	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. **– Change in state from "0" to "1":** A "0" is transmitted in the process data image of the inputs, if the faulty input was not previously set to state "0".
Input (assigned to the clock output that is not clocked) to non-assigned clock output	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. **– Change in state from "0" to "1":** A "0" is transmitted in the process data image of the inputs.
Clock output (clocked) to clock output (not clocked)	Yes	Cross circuit	No	The error is detected for inputs, which are assigned to the clocked clock output.
Short circuit				
Input to ground	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.

Table 7-9 Two-channel equivalent: Supply through UT1 and UT2 (of which one clock pulse is disabled) [...]

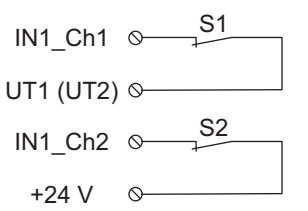
Error type	Detection	Diagnostics	Loss of SF	Remark
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel. The error is also detected as a short circuit of the clock output.

For all inputs that are assigned to the clock output that is not clocked, cross circuits and short circuits are not detected by the device diagnostics, but only on a change in state of the input signals, as the state only changes in one channel. Early error detection, e.g., by testing the safety function at regular intervals, is required, as an accumulation of errors may result in the loss of the safety function.

Typical parameterization

Parameterization	Parameterized as		Remark
Input	**Channel 1**	**Channel 2**	
Assignment	**Used**	**Used**	
Evaluation	**Two-channel**	**Two-channel**	
Sensor type	**Standard sensor**	**Standard sensor**	
Filter time (t_{Filter})	3 ms	3 ms	Application-specific, same value
Symmetry	10 ms	10 ms	Application-specific, same value
Clock selection (pulse selection)	UT1	UT2	Or vice versa
Bouncing time monitoring (bounce time monitoring)	Disabled	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Disabled	Application-specific, same for both inputs
Input signal	**Equivalent**	**Equivalent**	
Clock output			
	UT1 ON and UT2 OFF (24 V)		Or vice versa

7.4.4 Two-channel equivalent: Supply through a clock output (clocking enabled) and external supply

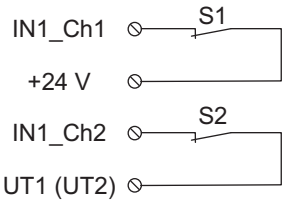


S1, S2
Two switching elements

UT1 (UT2)
Supply through UT1 **or** UT2

+24 V
Supply through external 24 V

Figure 7-10 Two-channel equivalent assignment of inputs, supply through UT1 (or UT2) and externally



S1, S2
Two switching elements

+24 V
Supply through external 24 V

UT1 (UT2)
Supply through UT1 **or** UT2

Figure 7-11 Two-channel equivalent assignment of inputs, supply through UT1 (or UT2) and externally

Basic specifications

Sensor	Two-channel equivalent
Sensor supply	Internally through clock output UT1 (or UT2) **and** externally
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 4/PL e

WARNING: Loss of electrical and functional safety

– To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
– Please note that in order to achieve the specified PL, the sensor must have a high level of diagnostic coverage (> 99%) and high MTTFd.
– Use sensors that can achieve the required safety integrity level.

Device diagnostics and behavior of the module in the event of an error

To understand the change in state, please refer to "Example of correct and incorrect signal change" on page 7-13.

Table 7-10 Two-channel equivalent: Supply through a clock output (clocked) and external supply

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. – **Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. – **Change in state from "0" to "1":** A "0" is transmitted in the process data image of the affected inputs, as the faulty input was not previously set to state "0".
A contact will not close	Yes	Symmetry violation	No	On a change in state from "0" to "1", a "0" is transmitted in the process data image of the affected inputs, as only one channel reports this change in state.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Input (Cable interrupt between clock output and sensor or between sensor and input)	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.
Cross circuit				
Input to input	Yes	Cross circuit	No	The error is detected in state "1".
Input to assigned clock output	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. – **Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. – **Change in state from "0" to "1":** A "0" is transmitted in the process data image of the inputs, if the faulty input was not previously set to state "0".
Input (not assigned to a clock output) to clock output	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. – **Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. – **Change in state from "0" to "1":** A "0" is transmitted in the process data image of the inputs.
Clock output to clock output	Yes	Cross circuit	No	The error is detected for inputs, which are assigned to the clocked clock output.

Table 7-10 Two-channel equivalent: Supply through a clock output (clocked) and external supply [...]

Error type	Detection	Diagnostics	Loss of SF	Remark
Short circuit				
Input (assigned to the clocked clock output) to external 24 V	Yes	Cross circuit	No	The error is detected by the absence of the clock pulses of the clock output.
Input (not assigned to any clock output) to external 24 V	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. – **Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. – **Change in state from "0" to "1":** A "0" is transmitted in the process data image of the inputs.
Input to ground	Yes	Symmetry violation	No	**The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.**
Clocked clock output to external 24 V	Yes	Cross circuit	No	The error is detected by the absence of the clock pulses of the clock output in the assigned input.
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel. The error is also detected as a short circuit of the clock output. The affected clock output is disabled.
External 24 V to ground	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.

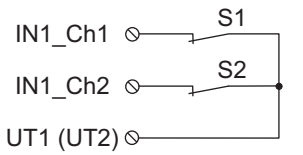
For all inputs that are not assigned to a clock output, cross circuits and short circuits are not detected by the device diagnostics, but only on a change in state of the input signals, as the state only changes in one channel. Early error detection, e.g., by testing the safety function at regular intervals, is required, as an accumulation of errors may result in the loss of the safety function.

Typical parameterization

Parameterization	Parameterized as		Remark
Input	**Channel 1**	**Channel 2**	
Assignment	**Used**	**Used**	
Evaluation	**Two-channel**	**Two-channel**	
Sensor type	**Standard sensor**	**Standard sensor**	
Filter time (t_{Filter})	3 ms	3 ms	Application-specific, same value
Symmetry	10 ms	10 ms	Application-specific, same value
Clock selection (pulse selection)	UT1	No assignment	Or vice versa
Bouncing time monitoring (bounce time monitoring)	Disabled	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Disabled	Application-specific, same for both inputs

Parameterization	Parameterized as		Remark
Input signal	**Equivalent**	**Equivalent**	
Clock output			
	UT1 ON (UT2 any)		For specified clock selection

7.4.5 Two-channel equivalent: Supply through a clock output (clocking enabled)



S1, S2
Two switching elements

UT1 (UT2)
Supply through UT1 **or** UT2

Figure 7-12 Two-channel equivalent assignment of inputs, supply through UT1 (or UT2) (clocked)

Basic specifications

Sensor	Two-channel equivalent
Sensor supply	Internally through a clock output UT1 (or UT2) (clocked)
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 3/PL d

WARNING: Loss of electrical and functional safety
- To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
- Please note that in order to achieve the specified PL, the sensor must have a medium level of diagnostic coverage (90% to 99%) and medium MTTFd. A high level of diagnostic coverage (> 99%) is recommended for the application according to PL d.
- Use sensors that can achieve the required safety integrity level.

To understand the change in state, please refer to "Example of correct and incorrect signal change" on page 7-13.

Device diagnostics and behavior of the module in the event of an error

Table 7-11 Two-channel equivalent: Supply through a clock output (clocked)

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. **– Change in state from "0" to "1":** A "0" is transmitted in the process data image of the affected inputs, as the faulty input was not previously set to state "0".
A contact will not close	Yes	Symmetry violation	No	On a change in state from "0" to "1", a "0" is transmitted in the process data image of the affected inputs, as only one channel reports this change in state.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Cable interrupt between clock output and sensor	Yes	None	No	**– Behavior when the input is in state "1":** The error is detected as a change in state from "1" to "0". An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.**
Cable interrupt between sensor and input	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.
Cross circuit				
Input to input	**No**	None	No	The error is not detected. **An accumulation of errors can result in the loss of the safety function.**
Input to assigned clock output	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. **– Change in state from "0" to "1":** A "0" is transmitted in the process data image of the inputs, if the faulty input was not previously set to state "0".
Input to non-assigned clock output	Yes	Cross circuit	No	See "Note about cross circuits" on page 7-14.
Clock output to clock output	Yes	Cross circuit	No	The error is detected for inputs, which are assigned to the clocked clock output.

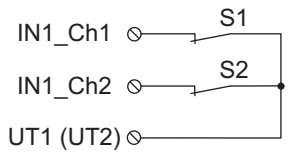
Table 7-11 Two-channel equivalent: Supply through a clock output (clocked) [...]

Error type	Detec-tion	Diag-nostics	Loss of SF	Remark
Short circuit				
Input to ground	Yes	None	No	**– Behavior when the input is in state "1":** The error is detected as a change in state from "1" to "0". An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.**
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected as a change in state from "1" to "0". An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.** The error is also detected as a short circuit of the clock output. The affected clock output is disabled.

Typical parameterization

Parameterization	Parameterized as		Remark
Input	Channel 1	Channel 2	
Assignment	**Used**	**Used**	
Evaluation	**Two-channel**	**Two-channel**	
Sensor type	**Standard sensor**	**Standard sensor**	
Filter time (t_{Filter})	3 ms	3 ms	Application-specific, same value
Symmetry	10 ms	10 ms	Application-specific, same value
Clock selection (pulse selection)	UT1	UT1	Or both UT2
Bouncing time monitoring (bounce time monitoring)	Disabled	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Disabled	Application-specific, same for both inputs
Input signal	**Equivalent**	**Equivalent**	
Clock output			
	UT1 ON (UT2 any)		Where clock selection = UT1

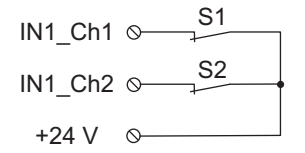
7.4.6 Two-channel equivalent: Supply through a clock output (clocking disabled) or external supply



S1, S2
Two switching elements

UT1 (UT2)
Supply through UT1 **or** UT2

Figure 7-13 Two-channel equivalent assignment of inputs, supply through UT1 (or UT2) (clocking disabled)



S1, S2
Two switching elements

+24 V
External supply

Figure 7-14 Two-channel equivalent assignment of inputs, external supply

Basic specifications

Sensor	Two-channel equivalent
Sensor supply	Internally through clock output UT1 (or UT2) (clocking disabled) **or** externally
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 3/PL d

WARNING: Loss of electrical and functional safety
- To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
- Please note that in order to achieve the specified PL, the sensor must have a medium level of diagnostic coverage (90% to 99%) and medium MTTFd. A high level of diagnostic coverage (> 99%) is recommended for the application according to PL d.
- Use sensors that can achieve the required safety integrity level.

To understand the change in state, please refer to "Example of correct and incorrect signal change" on page 7-13.

Device diagnostics and behavior of the module in the event of an error

Table 7-12 Two-channel equivalent: Supply through a clock output (clocking disabled) or external supply

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. **– Change in state from "0" to "1":** A "0" is transmitted in the process data image of the affected inputs, as the faulty input was not previously set to state "0".
A contact will not close	Yes	Symmetry violation	No	On a change in state from "0" to "1", a "0" is transmitted in the process data image of the affected inputs, as only one channel reports this change in state.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Cable interrupt between clock output or external supply and sensor	Yes	None	No	**– Behavior when the input is in state "1":** The error is detected as a change in state from "1" to "0". An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.**
Cable interrupt between sensor and input	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.
Cross circuit				
Input to input	**No**	None	No	**An accumulation of errors can result in the loss of the safety function.**
Input to clock output (assigned or not assigned)	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. **– Change in state from "0" to "1":** A "0" is transmitted in the process data image of the inputs, if the faulty input was not previously set to "0".
Clock output to clock output	**No**	None	No	The error is not detected.
Short circuit				
Input to external 24 V	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. **– Change in state from "0" to "1":** A "0" is transmitted in the process data image of the inputs, as the faulty input was not previously set to "0".
Input to ground	Yes	None	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.

Table 7-12 Two-channel equivalent: Supply through a clock output (clocking disabled) or external supply [...]

Error type	Detection	Diagnostics	Loss of SF	Remark
Clock output that is not clocked to external 24 V	**No**	None	No	The error is not detected.
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected as a change in state from "1" to "0". An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.** The error is also detected as a short circuit of the clock output. The affected clock output is disabled.
External 24 V to ground	Yes	None	No	The error is detected as a change in state from "1" to "0". An unexpected change from "0" to "1" is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.**

For all inputs that are not assigned to a clock output, cross circuits and short circuits are not detected by the device diagnostics, but only on a change in state of the input signals, as the state only changes in one channel. Early error detection, e.g., by testing the safety function at regular intervals, is required, as an accumulation of errors may result in the loss of the safety function.

Typical parameterization

Parameterization	Parameterized as		Remark
Input	**Channel 1**	**Channel 2**	
Assignment	**Used**	**Used**	
Evaluation	**Two-channel**	**Two-channel**	
Sensor type	**Standard sensor**	**Standard sensor**	
Filter time (t_{Filter})	3 ms	3 ms	Application-specific, same value
Symmetry	10 ms	10 ms	Application-specific, same value
Clock selection (pulse selection)	UT1	UT1	Or both UT2; or both no assignment
Bouncing time monitoring (bounce time monitoring)	Disabled	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Disabled	Application-specific, same for both inputs
Input signal	**Equivalent**	**Equivalent**	
Clock output			
	UT1 OFF (24 V) (UT2 any)		Where clock selection = UT1

7.4.7 Two-channel equivalent: External supply (OSSD)

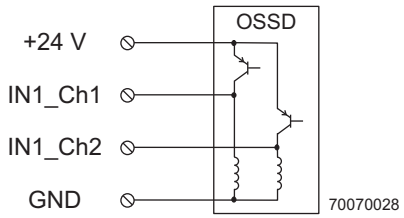


Figure 7-15 Two-channel equivalent assignment of inputs, external supply (OSSD)

WARNING: Loss of functional safety due to parasitic voltages
Connect the sensor ground directly to terminal point GND of the safety module. An external ground may not be used.

Basic specifications

Sensor	Two-channel OSSD output (with internal testing)
Sensor supply	External (OSSD sensor)
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 4/PL e

WARNING: Loss of electrical and functional safety
- To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
- Please note that in order to achieve the specified PL, the sensor must have a high level of diagnostic coverage (> 99%) and high MTTFd.
- Use sensors that can achieve the required safety integrity level.

Device diagnostics and behavior of the module in the event of an error

To understand the change in state, please refer to "Example of correct and incorrect signal change" on page 7-13.

Table 7-13 Two-channel equivalent: External supply (OSSD)

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
Channel failure	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. **– Change in state from "0" to "1":** A "0" is transmitted in the process data image of the affected inputs, as the faulty input was not previously set to state "0".
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**

Table 7-13 Two-channel equivalent: External supply (OSSD) [...]

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the wiring				
Interrupt				
Input (Cable interrupt between sensor and input)	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.
Input (Cable interrupt between sensor and GND)	No	None	No	The error must be detected by the sensor. **The sensor must ensure that the safe state is entered in the event of an error.**
Cross circuit				
Input to input	No	None	**Yes**	The error must be detected by the sensor. **The sensor must ensure that the safe state is entered in the event of an error.**
Input to clock output	Yes	Symmetry violation	No	The error is detected on a change in state if the clock output is set to "1", as the state only changes in one channel.
Short circuit				
Input to 24 V	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel.
Input to ground	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.

Typical parameterization

Parameterization	Parameterized as		Remark
Input	Channel 1	Channel 2	
Assignment	**Used**	**Used**	
Evaluation	**Two-channel**	**Two-channel**	
Sensor type	**Standard sensor**	**Standard sensor**	
Filter time (t_{Filter})	3 ms	3 ms	Application-specific, same value
Symmetry	10 ms	10 ms	Application-specific, same value
Clock selection (pulse selection)	No assignment	No assignment	
Bouncing time monitoring (bounce time monitoring)	Disabled	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Disabled	Application-specific, same for both inputs
Input signal	**Equivalent**	**Equivalent**	
Clock output			
	Any		

Set the filter time for the input to a value greater than the width of the test pulse for the OSSD sensor.

The input must not be assigned to a clock.

7.5 Two-channel non-equivalent assignment of safe inputs

For two-channel assignment of the safe inputs, two adjacent inputs are always used. This assignment is fixed and cannot be parameterized (see "Two-channel" on page 5-3).

For two-channel non-equivalent assignment, the state changes from "0" to "1" only when input INx_Ch1 changes state from "0" to "1" and input INx_Ch2 changes state from "1" to "0". If symmetry monitoring is enabled and the state at both inputs does not change within the parameterized time, a diagnostic message is generated.

The state is active when the state of the signal at channel 1 is equal to "1" and the signal at channel 2 is equal to "0".

Cross circuits can only be detected if the input signals are assigned to different clock outputs and clocks are enabled for the clock outputs.

Please note that if a delayed change in state at one of the two inputs causes the safety switch to be switched on again, this can result in delayed transmission of state "1" in the process data image of the inputs (e.g., due to a loose contact).

Example of correct and incorrect signal change

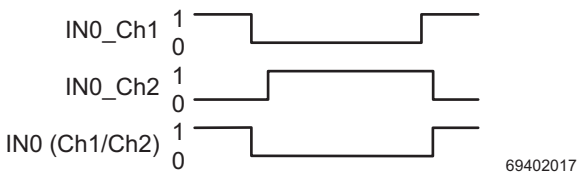


Figure 7-16 **Correct** signal change

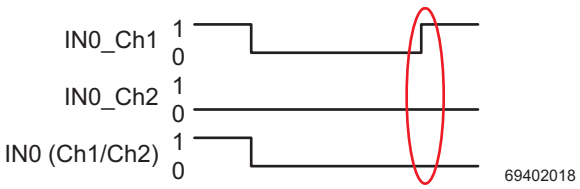


Figure 7-17 **Error** during signal change

In Figure 7-17, the condition that both signals must be in the opposite state before the change in state is not met. In this case, diagnostic message $018x_{hex}$ is generated.

Key for Figure 7-5 and Figure 7-6

IN0_Ch1	Signal sequence at input 0 channel 1
IN0_Ch2	Signal sequence at input 0 channel 2
IN0 (Ch1/Ch2)	Safety-related signal for two-channel input 0 channel 1 and channel 2 at the safe controller (PROFIsafe) or the configurable safety module (VersaSafe)

State evaluation

The module evaluates the states of the inputs and transmits the result to the safe controller (PROFIsafe) or the configurable safety module (VersaSafe).

In the process data image of the safe inputs:

– A "1" is transmitted if a "1" signal is present at channel 1 of the input and a "0" signal is present at channel 2 of the input **and** no error has been detected and the conditions are met for a change in state according to Figure 7-17.
– A "0" is transmitted in all other cases.

7.5.1 Notes about errors for two-channel non-equivalent assignment of safe inputs

For the following examples, please note the resulting behavior in the event of an error:

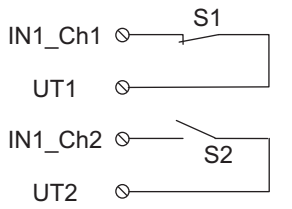
Note about cross circuits

– The **cross circuit** error results in the transmission of the safe state in the process data image of the affected inputs.
Remove the error and then acknowledge the message.
Acknowledging the diagnostic message deletes the message and activates the input. The states at the input are detected immediately. **In your safe application program, ensure that the system cannot be restarted unintentionally following acknowledgment of the diagnostic message.**
– Please observe the maximum failure detection time of 80 ms.
Exceptions in the failure detection time are indicated in the tables.
If a "1" signal is present at the input and an error occurs, a maximum of 80 ms elapses until the error is detected. Within this time, another "1" can also be transmitted, even in the event of an error.
Within the failure detection time (80 ms, maximum), the error can cause the state to change unexpectedly from "0" to "1".
Ensure that such a change in state cannot restart the system unintentionally.

Note about symmetry violation

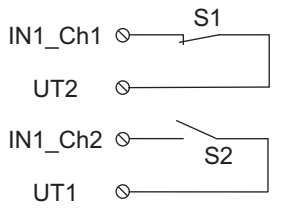
- The symmetry violation diagnostic message is only displayed if it was not disabled during parameterization of the affected input.
- **Start inhibit due to symmetry violation is disabled:**
  The symmetry violation message does **not** result in the transmission of the safe state (see also "Symmetry/ start inhibit" on page 5-5).
  The message must be acknowledged. However, the current status of the inputs is displayed in the process data image of the inputs.
- **Start inhibit due to symmetry violation is enabled:**
  The symmetry violation message results in the transmission of the safe state (see also "Symmetry/ start inhibit" on page 5-5).
  The message must be acknowledged. The current status of the inputs is displayed in the process data image of the inputs following acknowledgment.
- The message can be used to monitor the wear of the safety switch.

7.5.2 Two-channel non-equivalent: Supply through UT1 and UT2 (clocking enabled for both)



S1, S2
Two switching elements

Figure 7-18 Two-channel non-equivalent assignment of inputs, supply through UT1 and UT2 (both clocked)



S1, S2
Two switching elements

Figure 7-19 Two-channel non-equivalent assignment of inputs, supply through UT1 and UT2 (both clocked)

Basic specifications

Sensor	Two-channel non-equivalent
Sensor supply	Internally through clock output UT1 **and** UT2 (both clocked)
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 4/PL e

WARNING: Loss of electrical and functional safety

- To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
- Please note that in order to achieve the specified PL, the sensor must have a high level of diagnostic coverage (> 99%) and high MTTFd.
- Use sensors that can achieve the required safety integrity level.

To understand the change in state, please refer to "Example of correct and incorrect signal change" on page 7-31.

Device diagnostics and behavior of the module in the event of an error

Table 7-14 Two-channel non-equivalent: Supply through UT1 and UT2 (both clocked)

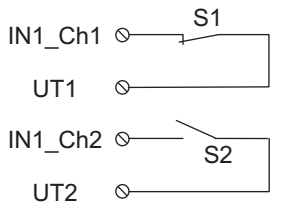
Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open	Yes	Symmetry violation	No	The error is detected, as the state only changes in one channel.
A contact will not close				
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Input (Cable interrupt between clock output and sensor or between sensor and input)	Yes	Symmetry violation	No	The error is detected on a change in state at the latest, as the state only changes in one channel.
Cross circuit				
Input to input	Yes	Cross circuit	No	The error is detected if the other input is set to "1".
Input to assigned clock output	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel.
Input to non-assigned clock output	Yes	Cross circuit	No	See "Note about cross circuits" on page 7-32.
Clock output to clock output	Yes	Cross circuit	No	The error is detected for inputs, which are assigned to different clock outputs.
Short circuit				
Input to ground	Yes	None	No	The error is detected on a change in state at the latest, as the state only changes in one channel.
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected on a change in state at the latest, as the state only changes in one channel. The error is also detected as a short circuit of the clock output. The affected clock output is disabled.

An error in input circuit INx_Ch2 can only be detected in the event of a safety demand. Early error detection, e.g., by testing the safety function at regular intervals, is required, as an accumulation of errors may result in the loss of the safety function.

Typical parameterization

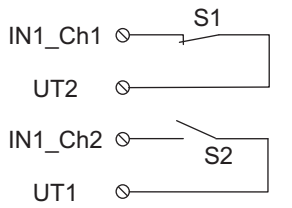
Parameterization	Parameterized as		Remark
Input	**Channel 1**	**Channel 2**	
Assignment	**Used**	**Used**	
Evaluation	**Two-channel**	**Two-channel**	
Sensor type	**Standard sensor**	**Standard sensor**	
Filter time (t_{Filter})	3 ms	3 ms	Application-specific, same for both inputs
Symmetry	10 ms	10 ms	Application-specific, same for both inputs
Clock selection (pulse selection)	UT1	UT2	Or vice versa
Bouncing time monitoring (bounce time monitoring)	Disabled	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Disabled	Application-specific, same for both inputs
Input signal	**Non-equivalent**	**Non-equivalent**	Same for both inputs
Clock outputs			
	UT1 ON and UT2 ON		

7.5.3 Two-channel non-equivalent: Supply through UT1 and UT2 (of which one clock pulse is disabled)



S1, S2
Two switching elements

Figure 7-20 Two-channel non-equivalent assignment of inputs, supply through UT1 and UT2 (of which one clock pulse is disabled)



S1, S2
Two switching elements

Figure 7-21 Two-channel non-equivalent assignment of inputs, supply through UT1 and UT2 (of which one clock pulse is disabled)

Basic specifications

Sensor	Two-channel non-equivalent
Sensor supply	Internally through clock output UT1 **and** UT2, of which one clock pulse is disabled
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 4/PL e

WARNING: Loss of electrical and functional safety

- To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
- Please note that in order to achieve the specified PL, the sensor must have a high level of diagnostic coverage (> 99%) and high MTTFd.
- Use sensors that can achieve the required safety integrity level.

To understand the change in state, please refer to "Example of correct and incorrect signal change" on page 7-31.

Device diagnostics and behavior of the module in the event of an error

Table 7-15 Two-channel non-equivalent: Supply through UT1 and UT2 (of which one clock pulse is disabled)

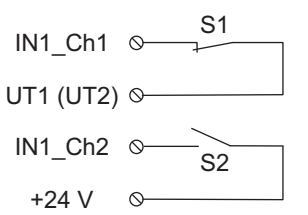
Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open A contact will not close	Yes	Symmetry violation	No	The error is detected, as the state only changes in one channel.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Input (Cable interrupt between clock output and sensor or between sensor and input)	Yes	Symmetry violation	No	The error is detected on a change in state at the latest, as the state only changes in one channel.
Cross circuit				
Input to input	Yes	Cross circuit	No	Cross-circuit detection depends on the switch position. A **cross circuit** is detected if the expected behavior of the input with regard to the test pulse of the assigned clock output is not achieved (test pulse exceeded). This error can also result in **symmetry violation**, as the signal cannot be changed in both channels simultaneously.
Input to assigned clock output	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs.
Input (assigned to the clocked clock output) to non-assigned clock output	Yes	Cross circuit	No	See "Note about cross circuits" on page 7-32.
Input (assigned to the clock output that is not clocked) to non-assigned clock output	Yes	Symmetry violation	No	The error is detected, as the state only changes in one channel.
Clock output to clock output	Yes	Cross circuit	No	The error is detected for inputs, which are assigned to the clocked clock output. The error is detected if the input assigned to the clocked clock output is active. **In this case, please note that the failure detection time depends on the switch position.**
Short circuit				
Input to ground	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel. The error is also detected as a short circuit of the clock output.

For all inputs that are assigned to the clock output that is not clocked, cross circuits and short circuits are not detected by the device diagnostics, but only on a change in state of the input signals, as the state only changes in one channel. Early error detection, e.g., by testing the safety function at regular intervals, is required, as an accumulation of errors may result in the loss of the safety function.

Typical parameterization

Parameterization	**Parameterized as**		**Remark**
Input	**Channel 1**	**Channel 2**	
Assignment	**Used**	**Used**	
Evaluation	**Two-channel**	**Two-channel**	
Sensor type	**Standard sensor**	**Standard sensor**	
Filter time (t_{Filter})	3 ms	3 ms	Application-specific, same for both inputs
Symmetry	10 ms	10 ms	Application-specific, same for both inputs
Clock selection (pulse selection)	UT1	UT2	Or vice versa
Bouncing time monitoring (bounce time monitoring)	Disabled	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Disabled	Application-specific, same for both inputs
Input signal	**Non-equivalent**	**Non-equivalent**	Same for both inputs
Clock outputs			
	UT1 ON and UT2 OFF (24 V)		For specified clock selection

7.5.4 Two-channel non-equivalent: Supply through a clock output (clocking enabled) and external supply

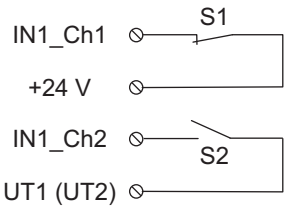


S1, S2
Two switching elements

UT1 (UT2)
Supply through UT1 **or** UT2

+24 V
Supply through external 24 V

Figure 7-22 Two-channel non-equivalent assignment of inputs, internal supply through a clock output (clocked) and external supply



S1, S2
Two switching elements

+24 V
Supply through external 24 V

UT1 (UT2)
Supply through UT1 **or** UT2

Figure 7-23 Two-channel non-equivalent assignment of inputs, internal supply through a clock output (clocked) and external supply

Basic specifications

Sensor	Two-channel non-equivalent
Sensor supply	Internally through clock output UT1 (or UT2) (clocked) and externally
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 4/PL e

WARNING: Loss of electrical and functional safety
- To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
- Please note that in order to achieve the specified PL, the sensor must have a high level of diagnostic coverage (> 99%) and high MTTFd.
- Use sensors that can achieve the required safety integrity level.

To understand the change in state, please refer to "Example of correct and incorrect signal change" on page 7-31.

Device diagnostics and behavior of the module in the event of an error

Table 7-16 Two-channel non-equivalent: Supply through a clock output (clocked) and external supply

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open A contact will not close	Yes	Symmetry violation	No	The error is detected, as the state only changes in one channel.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Input (Cable interrupt between clock output and sensor or between sensor and input)	Yes	Symmetry violation	No	The error is detected on a change in state at the latest, as the state only changes in one channel.
Cross circuit				
Input to input	Yes	Cross circuit	No	Cross-circuit detection depends on the switch position. A **cross circuit** is detected if the expected behavior of the input with regard to the test pulse of the assigned clock output is not achieved (test pulse exceeded). This error can also result in **symmetry violation**, as the signal cannot be changed in both channels simultaneously.
Input to assigned clock output	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. – **Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs.
Input (assigned to the clocked clock output) to non-assigned clock output	Yes	Cross circuit	No	See "Note about cross circuits" on page 7-32.
Input (not assigned to a clock output) to non-assigned clock output	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel.
Clock output to clock output	Yes	Cross circuit	No	The error is detected for inputs, which are assigned to the clocked clock output. Error detection depends on the switch position. The error is detected if the input assigned to the clocked clock output is active. **In this case, please note that the failure detection time depends on the switch position.**
Short circuit				
Input (assigned to the clocked clock output) to external 24 V	Yes	Cross circuit	No	The error is detected by the absence of the clock pulses of the clock output.
Input (not assigned to any clock output) to external 24 V	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. – **Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs.
Input to ground	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.

Table 7-16 Two-channel non-equivalent: Supply through a clock output (clocked) and external supply [...]

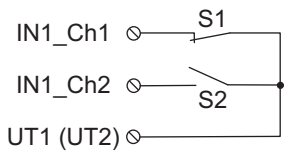
Error type	Detection	Diagnostics	Loss of SF	Remark
Clocked clock output to external 24 V	Yes	Cross circuit	No	The error is detected by the absence of the clock pulses of the clock output in the assigned input. **In this case, please note that the failure detection time depends on the switch position.**
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel. The error is also detected as a short circuit of the clock output.
External 24 V to ground	Yes	Symmetry violation	No	**The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.**

For all inputs that are not assigned to a clock output, cross circuits and short circuits are not detected by the device diagnostics, but only on a change in state of the input signals, as the state only changes in one channel. Early error detection, e.g., by testing the safety function at regular intervals, is required, as an accumulation of errors may result in the loss of the safety function.

Typical parameterization

Parameterization	Parameterized as		Remark
Input	**Channel 1**	**Channel 2**	
Assignment	**Used**	**Used**	
Evaluation	**Two-channel**	**Two-channel**	
Sensor type	**Standard sensor**	**Standard sensor**	
Filter time (t_{Filter})	3 ms	3 ms	Application-specific, same for both inputs
Symmetry	10 ms	10 ms	Application-specific, same for both inputs
Clock selection (pulse selection)	UT1 (or UT2)	No assignment	Or vice versa
Bouncing time monitoring (bounce time monitoring)	Disabled	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Disabled	Application-specific, same for both inputs
Input signal	**Non-equivalent**	**Non-equivalent**	Same for both inputs
Clock outputs			
	UT1 ON (UT2 any)		For specified clock selection

7.5.5 Two-channel non-equivalent: Supply through a clock output (clocking enabled)



S1, S2
Two switching elements

UT1 (UT2)
Supply through UT1 **or** UT2

Figure 7-24 Two-channel non-equivalent assignment of inputs, supply through UT1 or UT2 (clocked)

Basic specifications

Sensor	Two-channel non-equivalent
Sensor supply	Internally through clock output UT1 (or UT2) (clocked)
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 4/PL e

WARNING: Loss of electrical and functional safety
- To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
- Please note that in order to achieve the specified PL, the sensor must have a high level of diagnostic coverage (> 99%) and high MTTFd.
- Use sensors that can achieve the required safety integrity level.

To understand the change in state, please refer to "Example of correct and incorrect signal change" on page 7-31.

Device diagnostics and behavior of the module in the event of an error

Table 7-17 Two-channel non-equivalent: Supply through a clock output (clocked)

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open A contact will not close	Yes	Symmetry violation	No	The error is detected, as the state only changes in one channel.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Input (cable interrupt between clock output and sensor or between sensor and input)	Yes	Symmetry violation	No	The error is detected on a change in state at the latest, as the state only changes in one channel.

Table 7-17 Two-channel non-equivalent: Supply through a clock output (clocked) [...]

Error type	Detection	Diagnostics	Loss of SF	Remark
Cross circuit				
Input to input	Yes	Symmetry violation	No	The error is detected, as the state only changes in one channel.
Input to assigned clock output	Yes	Symmetry violation	No	The error is detected on a change in state, as the state only changes in one channel. – **Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs.
Input to non-assigned clock output	Yes	Cross circuit	No	See "Note about cross circuits" on page 7-14.
Clock output to clock output	Yes	Cross circuit	No	The error is detected for inputs, which are assigned to the clocked clock output. **In this case, please note that the failure detection time depends on the switch position.**
Short circuit				
Input to ground	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected as a change in state from "1" to "0". The error is also detected as a short circuit of the clock output. The affected clock output is disabled.

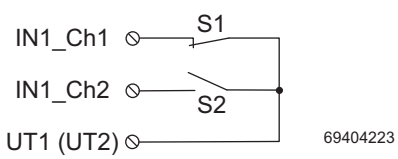
Early error detection, e.g., by testing the safety function at regular intervals, is required, as an accumulation of errors may result in the loss of the safety function.

Typical parameterization

Parameterization	Parameterized as		Remark
Input	**Channel 1**	**Channel 2**	
Assignment	**Used**	**Used**	
Evaluation	**Two-channel**	**Two-channel**	
Sensor type	**Standard sensor**	**Standard sensor**	
Filter time (t_{Filter})	3 ms	3 ms	Application-specific, same for both inputs
Symmetry	10 ms	10 ms	Application-specific, same for both inputs
Clock selection (pulse selection)	UT1	UT1	Or both UT2
Bouncing time monitoring (bounce time monitoring)	Disabled	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Disabled	Application-specific, same for both inputs

Parameterization	Parameterized as		Remark
Input	**Channel 1**	**Channel 2**	
Input signal	**Non-equivalent**	**Non-equivalent**	Same for both inputs
Clock outputs			
	UT1 ON (24 V) (UT2 any)		Or vice versa

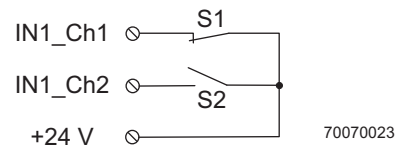
7.5.6 Two-channel non-equivalent: Supply through a clock output (clocking disabled) or external supply



S1, S2
Two switching elements

UT1 (UT2)
Supply through UT1 **or** UT2

Figure 7-25 Two-channel non-equivalent assignment of inputs, supply through UT1 (or UT2) (clocking disabled)



S1, S2
Two switching elements

+24 V
Supply through external 24 V

Figure 7-26 Two-channel non-equivalent assignment of inputs, external supply

Basic specifications

Sensor	Two-channel non-equivalent
Sensor supply	Internally through clock output UT1 (or UT2) (clocking disabled) **or** externally
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 3/PL d

WARNING: Loss of electrical and functional safety
- To achieve the specified category, please refer to "Measures required to achieve a specific safety integrity level" on page 7-3.
- Please note that in order to achieve the specified PL, the sensor must have a medium level of diagnostic coverage (90% to 99%) and medium MTTFd. A high level of diagnostic coverage (> 99%) is recommended for the application according to PL d.
- Use sensors that can achieve the required safety integrity level.

To understand the change in state, please refer to "Example of correct and incorrect signal change" on page 7-31.

Device diagnostics and behavior of the module in the event of an error

Table 7-18 Two-channel non-equivalent: Supply through a clock output (clocking disabled) or external supply

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open A contact will not close	Yes	Symmetry violation	No	The error is detected, as the state only changes in one channel.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Error in the wiring				
Interrupt				
Input (cable interrupt between clock output and sensor or between sensor and input)	Yes	Symmetry violation	No	The error is detected on a change in state at the latest, as the state only changes in one channel.
Cross circuit				
Input to input	Yes	Symmetry violation	No	The error is detected, as the state only changes in one channel.
Input to clock output (assigned or not assigned)	Yes	Symmetry violation	No	The error is detected, as the state only changes in one channel. **– Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs.
Clock output to clock output	**No**	None	No	The error is not detected.
Short circuit				
Input to external 24 V	Yes	Symmetry violation	No	The error is detected on a change in state at the latest, as the state only changes in one channel.
Input to ground	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.
Clock output to external 24 V	**No**	None	No	The error is not detected.
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected as a change in state from "1" to "0". The error is also detected as a short circuit of the clock output. The affected clock output is disabled.
External 24 V to ground	Yes	Symmetry violation	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.

Early error detection, e.g., by testing the safety function at regular intervals, is required, as an accumulation of errors may result in the loss of the safety function.

Typical parameterization

Parameterization	Parameterized as		Remark
Input	**Channel 1**	**Channel 2**	
Assignment	**Used**	**Used**	
Evaluation	**Two-channel**	**Two-channel**	
Sensor type	**Standard sensor**	**Standard sensor**	
Filter time (t_{Filter})	3 ms	3 ms	Application-specific, same for both inputs
Symmetry	10 ms	10 ms	Application-specific, same for both inputs
Clock selection (pulse selection)	UT1	UT1	Or both UT2 or no assignment (external)
Bouncing time monitoring (bounce time monitoring)	Disabled	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Disabled	Application-specific, same for both inputs
Input signal	**Non-equivalent**	**Non-equivalent**	Same for both inputs
Clock outputs			
	UT1 OFF (24 V) (UT2 any)		Where clock selection = UT1

8 Startup and validation

8.1 Initial startup

To start up, proceed as described in Table 8-1.

Table 8-1 Steps for startup

Step	Relevant section and literature
Set the transmission speed and the operating mode.	"Setting the DIP switches" on page 4-2
Set the protocol/address.	"Setting the DIP switches" on page 4-2
Install the safety module within the VersaPoint station.	"Assembly, removal, and electrical installation" on page 4-1
Connect the bus system and supply voltage cables to the VersaPoint station.	GFK-2736 or documentation for the bus coupler
Wire the inputs according to your application.	"Assembly, removal, and electrical installation" on page 4-1 "VersaPoint potential and data routing, and VersaPoint connectors" on page 3-1 User manuals for the function blocks used
Before applying the operating voltage: – Ensure that there are no wiring errors (e.g., cross circuit or short circuit) or grounding errors by testing with a multimeter. – Check whether the ground connection is safe.	
Connect the required voltages to the VersaPoint station.	GFK-2736 or documentation for the bus coupler
Once the operating voltage has been applied: – If possible, measure the wave form of the voltages to ensure that there are no deviations. – Measure the input voltages on the module to ensure that they are in the permissible range. – Use the LEDs on the module to check that the module starts up without any errors.	
Check the assembly and installation.	Checklist "Assembly and electrical installation" on page C-3
Carry out the necessary parameterization.	"Parameterization of the safety module" on page 5-1 Documentation for the configurable safety module used (VersaSafe) Documentation for the controller used (PROFIsafe)

Table 8-1 Steps for startup [...]

Step	Relevant section and literature
Program the safety function.	User manuals for the function blocks used Documentation for the configurable safety module used (VersaSafe) Documentation for the controller used (PROFIsafe)
For PROFIsafe: When verifying the safety function, check whether the F_iPar_CRC parameter is greater than 0 for all devices. If not, modify the settings.	Checklist "Validation" on page C-5 Quick Start Guide for configuring VersaPoint modules with safe inputs or outputs under PROFIsafe on your controller
Perform a function test and validation. Check whether the safety function responds as planned during programming and parameterization.	Checklist "Validation" on page C-5

When connecting the supply voltages, use the diagnostic and status indicators to check whether the module has started up correctly or whether any errors are indicated. For instructions on how to proceed in the event of an error, please refer to "Errors: Messages and removal" on page 9-1.

8.2 Restart after replacing a safety module

8.2.1 Replacing a safety module

WARNING: Unintentional machine startup

Do not assemble or remove the module while the power is connected.

Before assembling or removing the module, disconnect the power to the module and the entire VersaPoint station and ensure that it cannot be switched on again.

Make sure the entire station is reassembled before switching the power back on. Observe the diagnostic indicators and any diagnostic messages.

The system may only be started provided neither the station nor the system poses a hazard.

If replacing a module, proceed as described for assembly and removal (see "Assembly, removal, and electrical installation" on page 4-1).

Ensure that the new safety module is mounted at the correct position in the local bus. The new module must meet the following requirements:

– Same device type
– Same or later version

8.2.2 Restart

Once the safety module has been replaced, proceed as described for initial startup (see "Initial startup" on page 8-1).

The parameterization of the previous module remains the same and is transmitted to the new module when the system is started.

Plug the VersaPoint connectors into the correct connections.

Perform a function test after replacing the module.

8.3 Validation

Carry out a safety validation every time you make a safety-related modification to the VersaSafe or PROFIsafe system.

When validating your individual EUC, check the assignment of the sensor connections.

Determine whether:

– The correct safe sensors are connected to the safety module
– The safety module has been parameterized correctly
– The variables used in your application program have been linked to the safe sensors correctly

Perform a function test and error simulation.

Please observe the checklist "Validation" on page C-5 during validation.

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9 Errors: Messages and removal

Depending on the error type, errors that are diagnosed are displayed via the local diagnostic indicators and/or transmitted to the safe controller (PROFIsafe) or the configurable safety module (VersaSafe) as diagnostic messages.

The tables below provide an overview of the diagnosed errors, their causes, effects, and possible measures for error removal.

For VersaSafe, please also refer to the documentation for the configurable safety module used.

For every error that occurs, the cause of the error must first be removed. If necessary, the error is then acknowledged. Errors that must be acknowledged are indicated in the "Acknowledgment" column in the tables below.

If error codes are indicated by the system, which do not appear in the tables below, please contact GE Intelligent Platforms.

Error removal

To remove the cause of an error, please proceed as described in the "Remedy" column in the tables below.

Error acknowledgment

Instructions on how to acknowledge an error can be found in Section "Acknowledging an error" on page 9-9.

Module replacement following an error

If in the event of failure the safety module is replaced, please proceed as described in Section 8.2, "Restart after replacing a safety module" and Section "Restart after replacing a safety module" on page 8-3.

Notes on the tables below

The error code of a diagnostic message is comprised of the code for the error cause and the code for the error location.

Structure of the error code

	Error code	
	Code for error cause	Code for error location
E.g.,	012	x

Error code The error code is specified in Table 9-1 and onwards.

Error location In the error code specified, "x" specifies the location of the error. The value range for "x" is specified in the relevant row of the table.
For some errors a single channel is specified as the error location (e.g., IN0_Ch1).
Some errors only occur for inputs/outputs parameterized for two-channel operation. Here, the channel pair is specified as the error location (e.g., IN0_Ch1&2).

Example: Safe input errors (Table 9-1)

Error cause	**Error code (hex)**
Cross circuit	012x
x = 0 ... 3: IN0_Ch1 ... IN3_Ch1; x = 7 ... A: IN0_Ch2 ... IN3_Ch2	

012x Cross circuit

012**x** Error location

This means, for example:

0122 Cross circuit at IN2_Ch1 (input 2 channel 1)

012A Cross circuit at IN3_Ch2 (input 3 channel 2)

LED The "LED" column specifies which local diagnostic LEDs indicate the error.

Acknowledgment Errors that must be acknowledged are indicated with "Yes" in the "Acknowledgment" column. Special conditions for re-enabling an input or the module are specified in brackets [e.g., Yes (1)] in the "Acknowledgment" column and explained below the relevant table.

9.1 Safe digital input errors

Table 9-1 Safe digital input errors

Error cause	Error code (hex)	LED	Remark	Effect	Remedy	Acknowledgment
Permissible bouncing time was exceeded x = 0 ... 3: IN0_Ch1 ... IN3_Ch1; x = 7 ... A: IN0_Ch2 ... IN3_Ch2	**011x**	–	Not safety-related. Poor switch quality; contact bouncing is too long compared to the filter time.	Inputs continue to be detected and their states transmitted to the safe controller (PROFIsafe) or a configurable safety module (VersaSafe)	Check switches and replace, if necessary Check parameterized filter time	Yes (1)
Cross circuit x = 0 ... 3: IN0_Ch1 ... IN3_Ch1; x = 7 ... A: IN0_Ch2 ... IN3_Ch2	**012x**	–	Cross circuit with another input or with a clock output	Affected input is in the safe state	Check sensor Check clock outputs Check connector and cabling	Yes (2)
Symmetry violation x = 0 ... 3: IN0 Ch1&2 ... IN3_Ch1&2	**013x**	–	Not safety-related. Only for inputs parameterized for two-channel operation; used to evaluate the contacts of connected switches. State change in both channels takes longer than the value parameterized for symmetry. This message can also be triggered by a cross circuit/short circuit.	"Start inhibit due to symmetry violation" is disabled: Inputs continue to be detected and their states transmitted to the safe controller (PROFIsafe) or a configurable safety module (VersaSafe) "Start inhibit due to symmetry violation" is enabled: Affected input is in the safe state	Check whether the message was triggered by a short circuit/cross circuit If not: Check value for symmetry Check switches Replace switches during next maintenance. Activate connected I/O devices once (e.g., activate and unlock emergency stop).	Yes (4)
Hardware fault x = 0 ... 3: IN0_Ch1 ... IN3_Ch1; x = 7 ... A: IN0_Ch2 ... IN3_Ch2	**014x**	–		All module inputs are in the safe state	Power up with error-free selftest Replacement	Yes (3)
Sensor error x = 0 ... 3: IN0 Ch1&2 ... IN3_Ch1&2	**015x**	–	At the input that was parameterized for an intelligent sensor	Affected input is in the safe state	Check sensor	Yes (2)

Table 9-1 Safe digital input errors [...]

Error cause	Error code (hex)	LED	Remark	Effect	Remedy	Acknow-ledgment
Signal error x = 0 ... 3: IN0 Ch1&2 ... IN3_Ch1&2	**016x**	–	At the input that was parameterized for an intelligent sensor (incorrect or distorted clock signal, e.g., due to short circuit; different states at both inputs)	Affected input is in the safe state	Check sensor	Yes (2)
Hardware fault	**0170**	–		All module inputs are in the safe state	Power up with error-free selftest Replacement	Yes (3)
Error during signal change x = 0 ... 3: IN0 Ch1&2 ... IN3_Ch1&2	**018x**	–	Only for inputs parameterized for two-channel operation; implausible signal change at indicated input pair	Affected inputs in the safe state	Set both inputs to the safe state	Yes (1)

Acknowledgment: Yes (1) Acknowledging the diagnostic message deletes the message.

Acknowledgment: Yes (2) Acknowledging the diagnostic message deletes the message and activates the input. The states at the input are detected immediately. In your safe application program, ensure that the system cannot be restarted unintentionally following acknowledgment of the diagnostic message.

Acknowledgment: Yes (3) Acknowledging the diagnostic message deletes the message. The module can only be restarted following power up and error-free selftest.

Acknowledgment: Yes (4) "Start inhibit due to symmetry violation" is disabled:
Acknowledging the diagnostic message deletes the message.

"Start inhibit due to symmetry violation" is enabled:
Acknowledging the diagnostic message deletes the message and activates the disabled inputs again.

9.2 Clock output UT1 and UT2 errors

Table 9-2 Clock output errors

Error cause	Error code (hex)	LED	Remark	Effect	Remedy	Acknow-ledgment
Short circuit or overload x = 0: Clock output UT1; x = 7: Clock output UT2	**01Ex**	UT1 or UT2 ON		Affected clock output is disabled. Assigned inputs are set to "0".	Check connector and cabling (acknowledge error at all inputs, if necessary)	Yes (1)

Acknowledgment: Yes (1) Acknowledging the diagnostic message deletes the message and re-enables the clock output and the assigned inputs. In your safe application program, ensure that the system cannot be restarted unintentionally following acknowledgment of the diagnostic message.

The clock outputs are also switched on and monitored when not parameterized. If a short circuit occurs at a clock output when it is in this state, the clock output is switched off.

To exit the error, parameterize the device and acknowledge the error message.

9.3 Supply voltage errors

Table 9-3 Supply voltage U_M errors

Error cause	Error code (hex)	LED	Remark	Effect	Remedy	Acknow-ledgment
Undervoltage U_M	**01F0**	UM flashing	U_M below the permissible voltage range	All module inputs are in the safe state	Check and supply voltage level Check supply line length and load	Yes (1)

Acknowledgment: Yes (1) Acknowledging the diagnostic message deletes the message and activates the inputs.

Undervoltage at U_M Supply voltage U_M is measured. If U_M < 17 V, a diagnostic message is generated.

9.4 Parameterization errors

Table 9-4 Parameterization errors

Error cause	Error code (hex)	LED	Remark	Effect	Remedy	Acknow-ledgment
Incorrect parameteriza-tion	See Table 9-5	FS (flashing)	Each input and clock output is parameterized individually	Module is in the safe state	Check and correct parameterization.	–

In order to determine what type of parameterization error has occurred, use the corresponding software to access the safe controller (PROFIsafe) or the standard control system (VersaSafe) online and read the error.

Table 9-5 Parameterization errors

Error code		Short description	Remedy
(hex)	**(dec)**		
031x x = 0 ... 3: IN0_Ch1 ... IN3_Ch1; x = 7 ... A: IN0_Ch2 ... IN3_Ch2	**784**: IN0_Ch1 : **787**: IN3_Ch1; **791**: IN0_Ch2 : **794**: IN3_Ch2	The filter time setting for the input is outside the permissible range.	Correct value and resend parameter data to the module.
032x x = 0 ... 3: IN0_Ch1 ... IN3_Ch1; x = 7 ... A: IN0_Ch2 ... IN3_Ch2	**800**: IN0_Ch1 : **803**: IN3_Ch1; **807**: IN0_Ch2 : **810**: IN3_Ch2	The clock assignment for the input is outside the permissible range.	Correct value and resend parameter data to the module.
033x x = 0 ... 3: IN0_Ch1&2 ... IN3_Ch1&2	**816**: IN0_Ch1&2 : **819**: IN3_Ch1&2	The parameterization of two related inputs does not correspond to the two-channel setting.	Correct values and resend parameter data to the module.
034x x = 0 ... 3: IN0_Ch1&2 ... IN3_Ch1&2	**832**: IN0_Ch1&2 : **835**: IN3_Ch1&2	The setting for the symmetry monitoring of related inputs is not the same.	Inputs that are parameterized for two-channel operation must have the same symmetry settings. Correct values and resend parameter data to the module.
035x x = 0 ... 3: IN0_Ch1 ... IN3_Ch1; x = 7 ... A: IN0_Ch2 ... IN3_Ch2	**848**: IN0_Ch1 : **851**: IN3_Ch1; **855**: IN0_Ch2 : **858**: IN3_Ch2	The value for symmetry monitoring is outside the permissible range.	Correct value and resend parameter data to the module.

Table 9-5 Parameterization errors [...]

Error code		Short description	Remedy
(hex)	**(dec)**		
036x x = 0 ... 3: IN0_Ch1 ... IN3_Ch1; x = 7 ... A: IN0_Ch2 ... IN3_Ch2	**864**: IN0_Ch1 : **867**: IN3_Ch1; **871**: IN0_Ch2 : **874**: IN3_Ch2	Intelligent sensor has been connected to an input parameterized for single-channel operation.	Connect intelligent sensor to an input parameterized for two-channel operation and parameterize inputs accordingly. Correct values and resend parameter data to the module.
037x x = 0 ... 3: IN0_Ch1 ... IN3_Ch1; x = 7 ... A: IN0_Ch2 ... IN3_Ch2	**880**: IN0_Ch1 : **883**: IN3_Ch1; **887**: IN0_Ch2 : **890**: IN3_Ch2	Even though the input was parameterized for intelligent sensors, bouncing time monitoring was activated.	The bouncing time monitoring function can only be activated for operation with standard sensors. Correct value and resend parameter data to the module.
038x x = 0 ... 3: IN0_Ch1 ... IN3_Ch1; x = 7 ... A: IN0_Ch2 ... IN3_Ch2	**896**: IN0_Ch1 : **899**: IN3_Ch1; **903**: IN0_Ch2 : **906**: IN3_Ch2	Even though the input was parameterized for intelligent sensors, symmetry monitoring was activated for the input.	The symmetry monitoring function can only be activated for operation with standard sensors. Correct value and resend parameter data to the module.
039x x = 0 ... 3: IN0_Ch1 ... IN3_Ch1; x = 7 ... A: IN0_Ch2 ... IN3_Ch2	**912**: IN0_Ch1 : **915**: IN3_Ch1; **919**: IN0_Ch2 : **922**: IN3_Ch2	Even though the input was parameterized for intelligent sensors, non-equivalent signal processing was activated for the input.	Non-equivalent processing of two-channel inputs may only be activated for operation with standard sensors. Correct value and resend parameter data to the module.
03Ax x = 0 ... 3: IN0_Ch1&2 ... IN3_Ch1&2	**928**: IN0_Ch1&2 : **931**: IN3_Ch1&2	The settings for the input signal for the indicated input and the related input differ.	Assign the same setting for the input signal for related inputs and resend parameter data to the module.
03Cx x = 0 ... 3: IN0_Ch1&2 ... IN3_Ch1&2	**960**: IN0_Ch1&2 : **963**: IN3_Ch1&2	The filter time of inputs parameterized for two-channel operation differs.	Assign the same setting for the filter time for related inputs and resend parameter data to the module.
03Ex x = 0: Clock output UT1; x = 7: Clock output UT2	**992**: Clock output UT1; **999**: Clock output UT2	The setting for the clock output is outside the permissible range.	The clock output parameters are invalid or do not correspond to the set sensor type. Correct value and resend parameter data to the module.

9.5 General errors

Table 9-6 General errors

Error cause	Error code (hex)	LED	Remark	Effect	Remedy	Acknow-ledgment
Device temperature at critical value	**01F2**			Immediate shutdown. Further temperature increase causes the module to switch to the safe state.	Check and adapt: – Ambient conditions – Derating – Switching frequency	Yes (1)
Error due to receipt of an unexpected message	**01F3**		Error due to receipt of an unexpected message while acknowledging a diagnostic message. The device firmware handles this diagnostic message with the highest priority. Only when this message has been acknowledged correctly are other errors indicated (if present).	The acknowledgment process, during which an unexpected message was received, is aborted. The corresponding error remains in the error memory. Diagnostic message 01F3 is indicated.	Check and adapt the assignment of the diagnostic and confirmation variables at the corresponding function block (see documentation for the controller used). Acknowledge diagnostic message 01F3 so that the next message from the error memory can be indicated.	Yes (1)
Hardware fault		FS ON	Error in the logic area	Module is in the safe state	Replacement	

Acknowledgment: Yes (1) Acknowledging the diagnostic message deletes the message.

9.6 PROFIsafe errors

In addition to the module errors specified, the following errors can occur:

– PROFIsafe system errors: These messages can be found in Section "Diagnostic messages for parameter errors" on page B-3.

– PROFIBUS or PROFINET system errors: For information about these errors, please refer to the documentation for the system used.

9.7 Acknowledging an error

9.7.1 Acknowledging an error for VersaSafe

An IC220SDL543 error is acknowledged completely via the configurable safety module.

For instructions on error acknowledgment, please refer to the documentation for the configurable safety module used.

9.7.2 Acknowledging an error for PROFIsafe

– Remove the cause of the error.
– Then acknowledge the diagnostic message.

For instructions on error acknowledgment, please refer to the documentation for the controller used.

WARNING: Acknowledgment may result in a hazardous system state

With the exception of a few special cases, the acknowledgment of an error immediately returns the safe input to the operating state. Before acknowledging an error you must therefore make sure that the acknowledgment will not cause the machine to switch to a dangerous state.

When planning the machine or system, ensure that acknowledgment is only possible if the danger zone is visible.

If in the event of failure the safety module is replaced, please proceed as described in Section 4, "Assembly, removal, and electrical installation" and Section 8.2, "Restart after replacing a safety module".

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10 Maintenance, repair, decommissioning, and disposal

10.1 Maintenance

The device is designed in such a way that maintenance work is not required during the duration of use. However, depending on the application and connected I/O devices it may be necessary to test the function of the I/O devices and the safety chain at regular intervals.

The duration of use of the module is 20 years.

Repeat testing within this time is not required.

Carry out maintenance of connected I/O devices (e.g., light grid) according to the relevant manufacturer specifications.

10.2 Repair

Repair work may not be carried out on the safety module. In the event of an error, send the module to GE Intelligent Platforms.

It is strictly prohibited to open the safety module. In order to prevent the manipulation of the module and to detect the unauthorized opening of the module, a security seal is applied to the module. This security seal is damaged in the event of unauthorized opening. In this case, the correct operation of the safety module can no longer be ensured.

10.3 Decommissioning and disposal

The machine or system manufacturer specifies the procedure for decommissioning. Decommissioning may only take place according to these specified procedures.

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11 Technical data and ordering data

11.1 System data

11.1.1 VersaSafe

For the system data for your system, please refer to the corresponding documentation for the controller used.

11.1.2 PROFIsafe

PROFIsafe	
PROFIsafe profile	2.4

For the system data for your system, please refer to the corresponding documentation for the controller used.

11.2 IC220SDL543

General data	
Housing dimensions (width x height x depth)	48.8 mm x 120 mm x 71.5 mm
Weight (with connectors)	200 g
Operating mode	
VersaSafe	Process data mode with 4 words
PROFIsafe	Process data mode with 4 words and 1 word PCP (internal use)
Transmission speed	500 kbaud or 2 Mbaud
Ambient temperature	
Operation	-25°C to +55°C
Storage/transport	-25°C to +70°C
Humidity	
Operation	75% on average, 85% occasionally (no condensation)

In the range from -25°C to +55°C appropriate measures against increased humidity must be taken.

Storage/transport:	75% on average; 85% occasionally (no condensation)

For a short period, slight condensation may appear on the outside of the housing.

Air pressure	
Operation	80 kPa to 108 kPa (up to 2000 m above sea level)
Storage/transport:	66 kPa to 108 kPa (up to 3500 m above sea level)

General data [...]	
Degree of protection	IP20
Housing material	Plastic PBT, self-extinguishing (V0)
Air and creepage distances	According to IEC 60664-1
Protection class	III (PELV)
Gases that may endanger functions according to DIN 40046-36, DIN 40046-37	
Sulfur dioxide (SO_2)	Concentration 10 ±0.3 ppm Ambient conditions: – Temperature 25°C ±2 K – Humidity 75% ±5% – Test duration 10 days
Hydrogen sulfide (H_2S)	Concentration 1 ±0.3 ppm Ambient conditions: – Temperature 25°C ±2 K – Humidity 75% ±5% – Test duration 4 days
Resistance of the housing material to termites	Resistant
Resistance of the housing material to fungal decay	Resistant
Ambient compatibility	Not resistant to chloroform
Connection data for VersaPoint connectors	
Connection method	Spring-cage terminals
Conductor cross section	0.2 mm^2 to 1.5 mm^2 (solid or stranded), 24 - 16 AWG

Mechanical requirements	
Vibration according to IEC 60068-2-6	Operation: 2g, Criterion A
Shock according to IEC 60068-2-27	15g over 11 ms, Criterion A

Safety characteristics according to IEC 61508/EN 61508	
Achievable SIL	SIL 2 (single-channel) SIL 3 (two-channel) Depends on the parameterization and wiring (see "Connection options for sensors depending on the parameterization" on page 2-7 and "Connection examples for safe inputs" on page 7-1)
Probability of a dangerous failure on demand by the safety function (PFD)	SIL 2: 1% of 10^{-2}, maximum (corresponds to 1 x 10^{-4}) SIL 3: 1% of 10^{-3}, maximum (corresponds to 1 x 10^{-5})
Probability of a dangerous failure per hour for the entire module (PFH)	SIL 2: 1% of 10^{-6}, maximum (corresponds to 1 x 10^{-8}) SIL 3: 1% of 10^{-7}, maximum (corresponds to 1 x 10^{-9}) Depends on the parameterization (see Table 7-4 on page 7-3)
Hardware fault tolerance (HFT) of the module	1
Permissible duration of use	20 years

Safety characteristics according to DIN EN 62061	
Achievable SIL claim limit	SIL CL = SIL 2 (single-channel) SIL CL = SIL 3 (two-channel) Depends on the parameterization and wiring (see "Connection options for sensors depending on the parameterization" on page 2-7 and "Connection examples for safe inputs" on page 7-1)
Safe failure fraction (SFF)	99%

Safety characteristics according to DIN EN 62061

Probability of a dangerous failure per hour for the entire module (PFH)	SIL 2: 1% of 10^{-6}, maximum (corresponds to 1 x 10^{-8}) SIL 3: 1% of 10^{-7}, maximum (corresponds to 1 x 10^{-9}) Depends on the parameterization (see Table 7-4 on page 7-3)
Hardware fault tolerance (HFT) of the module	1
Permissible duration of use	20 years

Safety characteristics according to EN ISO 13849-1

Achievable performance level	PL e (two-channel) PL d (single-channel) Depends on the parameterization and wiring (see "Connection options for sensors depending on the parameterization" on page 2-7 and "Connection examples for safe inputs" on page 7-1)
Diagnostic coverage (DC)	99%
Mean time to dangerous failure (MTTFd)	For single-channel assignment: 76 years For two-channel assignment: 100 years

Supply voltage U_L (logic)

The safety terminal is supplied with communications power via the bus coupler or a designated power terminal in the station. The communications power is led in the VersaPoint station via potential routing. For the technical data, please refer to the data sheet for the bus coupler or power terminal used.

Current consumption	180 mA, maximum

Supply voltage U_M (sensors, clock outputs)

The safety terminal is supplied with main voltage U_M via the bus coupler or a power terminal in the station. The main voltage is led in the VersaPoint station via potential routing. For the technical data, please refer to the data sheet for the bus coupler or power terminal used.

WARNING: Loss of the safety function when using unsuitable power supplies

Only use power supplies according to EN 50178/VDE 0160 (PELV).

Nominal voltage	24 V DC according to EN 61131-2 and EN 60204
Tolerance	-15%/+20% including an entire AC voltage component with peak value of 5%
Ripple	3.6 V_{PP}
Permissible voltage range	19.2 V DC to 30.0 V DC, ripple included
Current consumption	25 mA, typical (**plus** current consumption of the inputs when supplied through the clock outputs **plus** current consumption of the connected initiators when supplied through the clock outputs)
Permissible interruption time	10 ms (output voltage of the clock outputs can fail)
Surge protection	Yes (in the bus coupler/power terminal)
Protection against polarity reversal	Yes (in the bus coupler/power terminal)

NOTE: Module damage due to polarity reversal

Polarity reversal places a burden on the electronics and, despite protection against polarity reversal, can damage the module. Therefore, polarity reversal must be prevented.

Undervoltage detection	Yes, at 17 V, approximately
Diagnostic indicators	Green U_M LED (see "Local diagnostic and status indicators" on page 2-8)
External fuse	8 A slow-blow, maximum

NOTE: Module damage in the event of overload

The power supply unit must be able to supply four times (400%) the nominal current of the external fuse.

Safe digital inputs

Number	4 two-channel or 8 single-channel
Input design	According to the requirements of EN 61131-2 Type 3
Supply	Via clock outputs UT1 and UT2 or external supply
Input current	Approximately 4.2 mA at 24 V, typical
Maximum permissible current for "0"	2 mA
Minimum permissible current for "1"	3.1 mA
Permissible input voltage range	-3 V to +30 V
Voltage range for "0"	-3 V to +5 V
Voltage range for "1"	11 V to 30 V
Maximum switching frequency	10 Hz
Filter time t_{Filter}	Can be parameterized; see "Parameterization of the safe inputs" on page 5-3
Minimum filter time	1.5 ms, accuracy +0 ms, -0.5 ms

Safe digital inputs [...]	
Processing time of the input	$t_{IN} = t_{Filter} + t_{FW}$ (see "Processing time of the input t_{IN} in the event of a safety demand" on page 5-7)
Simultaneity	100%
Symmetry evaluation	Yes, can be parameterized, accuracy ±25%
Derating	No
Permissible cable lengths	200 m from the clock output to the safe input (total based on forward and return path)
Status indicators	One green LED per input (see "Local diagnostic and status indicators" on page 2-8)

The switching state of the inputs is constantly monitored. In the event of an error, e.g., if a component fails, the error is indicated at the safe controller (PROFIsafe) or a configurable safety module (VersaSafe).

Clock outputs	
Number	2
Supply	From U_M
Maximum switching current	0.4 A short-circuit and overload protection
Saturation voltage	U_M -1 V
Simultaneity	100%
Derating	No
Permissible cable lengths	The total length of the connected cables must not exceed 200 m per clock output
Status indicators	None
Diagnostic indicators	One red LED for each (UT1, UT2) (see "Local diagnostic and status indicators" on page 2-8)

Power dissipation	
If U_M = 24 V, no input is set, without load at clock outputs UT1 and UT2	1560 mW
If U_M = 24 V, 8 inputs are set, load at clock outputs UT1 and UT2 is 100 mA each	2330 mW

Electrical isolation/isolation of the voltage areas

To provide electrical isolation between the logic level and the I/O area, it is necessary to supply the bus coupler and this safety module from separate power supply units. Interconnection of the power supply units in the 24 V area is not permitted (see also user manual).

Separate potentials in the system comprising bus coupler/power terminal and safety module

- Test distance	- Test voltage
5 V supply incoming remote bus/7.5 V supply (bus logic)	500 V AC, 50 Hz, 1 min.
5 V supply outgoing remote bus/7.5 V supply (bus logic)	500 V AC, 50 Hz, 1 min.
7.5 V supply (bus logic)/24 V supply U_M, FE	500 V AC, 50 Hz, 1 min.

The isolating distance between U_M and FE is covered by a varistor.

Approvals

For the latest approvals, please visit http://support.ge-ip.com.

11.3 Conformance with EMC Directive

Conformance with EMC Directive 2004/108/EC		
Noise immunity test according to DIN EN 61000-6-2		
Electrostatic discharge (ESD)	EN 61000-4-2 (IEC 61000-4-2)	Criterion B 6 kV contact discharge, 8 kV air discharge
Electromagnetic fields	EN 61000-4-3 (IEC 61000-4-3)	Criterion A, field strength 10 V/m
Fast transients (burst)	EN 61000-4-4 (IEC 61000-4-4)	Criterion B, test voltage 2 kV
Surge voltage	EN 61000-4-5 (IEC 61000-4-5)	Test intensity 2, Criterion B DC supply lines: 0.5 kV/0.5 kV (symmetrical/asymmetrical) Signal lines: 1.0 kV/2.0 kV (symmetrical/asymmetrical)
Conducted interference	EN 61000-4-6 (IEC 61000-4-6)	Criterion A, test voltage 10 V
Noise emission test according to DIN EN 61000-6-4		
Noise emission	EN 55011	Class A, industrial applications

11.4 Ordering data

11.4.1 Ordering data: Safety module

Description	Catalog No.	Pcs./Pkt.
VersaPoint module with safe digital inputs	IC220SDL543	1

11.4.2 Ordering data: Accessories

Description	Catalog No.	Pcs./Pkt.
Connector set, consisting of four VersaPoint connectors with integrated discharge electronics	IC220SCO543	1 set

11.4.3 Ordering data: Documentation

Description	Catalog No.	Pcs./Pkt.
VersaPoint		
"Automation terminals of the VersaPoint product range" user manual	GFK-2736	–
VersaSafe		
"VersaPoint module with integrated safety logic and safe digital outputs" user manual	GFK-2731	–
PROFIsafe		
"PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO, Version 2.4, February 2007" specification	See http://www.profisafe.net	

Make sure you always use the latest documentation.
It can be downloaded at http://support.ge-ip.com.

Documentation for PROFIsafe, PROFIBUS, and PROFINET is available on the Internet at www.profibus.com/pall/meta/downloads.

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A Appendix: PROFIsafe terms used in the manual

Some of the terms that are used in connection with PROFIsafe in this manual are described below.

A definition of PROFIsafe terms is also provided in the PROFIsafe profile.

Consecutive number

Consecutive number

Method for ensuring that the safe data is transmitted completely and in the correct order.

CRC

Cyclic Redundancy Check

A cyclic redundancy check is used to verify the validity of the process data contained in the safety telegram, check whether the assigned address relationships are correct, and verify the safety-related parameters. This value is part of the safety telegram.

F_Destination_Address

F-Parameter; PROFIsafe destination address; address of the safe device
(see also "F-Parameter")

F_Source_Address

F-Parameter; PROFIsafe source address; address of the safe controller
(see also "F-Parameter")

F-CPU

Failsafe control system, safe controller

F-I/O device

Failsafe I/O device; safe input and/or output modules

Modules with integrated safety functions, which are approved for safety-related operation.

F-Parameter

(According to PROFIsafe system description, Version 09, November 2007)

F-Parameters contain information for adapting the PROFIsafe layer to specific customer specifications and for checking the parameterization by means of a separate method (diverse). The main F-Parameters are:

F_S/D_Address (F-Address for short)	A unique address for F-Devices within a PROFIsafe island. The technology part of the F-Device compares the value with the address switch locally or with an assigned F-Address in order to check the authenticity of the connection.
F_WD_Time	Specifies the millisecond value for the watchdog timer. The timer monitors the time that elapses until the next valid PROFIsafe message is received.
F_SIL	Indicates the SIL that the user can expect from the relevant F-Device. It is compared with the manufacturer's specification that is stored locally.
F_iPar_CRC	A checksum that is calculated from all iParameters of the technology-specific part of the F-Device.
F_Par_CRC	A CRC signature, which is created via all F-Parameters and ensures error-free transmission of the F-Parameters.

F-Slave

Failsafe slave

A

F-System

Failsafe system

A failsafe system is a system that remains in the safe state or immediately enters a safe state when specific failures occur.

iParameter

Individual safety parameter of a device

Passivation

If the safety module (F-I/O device) detects an error, it switches the affected channel or all channels of the module to the safe state; the channels are then passivated. The detected errors are indicated at the safe controller.

For a safe input module when the F-System is passivated, instead of the process values present at the safe inputs, substitute values (0) are provided for the safety program.

For a safe output module when the F-System is passivated, instead of the output values provided by the safety program, substitute values (0) are transferred to the safe outputs.

PROFIsafe

Safety-related bus profile based on PROFIBUS DP or PROFINET. It defines the communication between a safety program and the safe I/O device (F-I/O device) in a safe system (F-System).

PROFIsafe address

Each safe module has a PROFIsafe address. This address must be set on the safety module (F-I/O device) via DIP switches and then configured in the configuration tool for the safe controller used.

PROFIsafe monitoring time

Monitoring time for safety-related communication between the safe controller (F-CPU) and safe I/O device (F-I/O device).

This time is parameterized in the F_WD_Time F-Parameter.

B Appendix: F-Parameters and iParameters

B 1 F-Parameters

The values indicated in italics in Table B-1 are preset by the system and cannot be modified manually.

Table B-1 Overview of the F-Parameters for the module

F-Parameter	Default value	Description
F_Source_ Address	*Automatic*	The parameter uniquely identifies the PROFIsafe source address (controller address). The address is assigned automatically.
F_Destination_ Address	*Automatic*	PROFIsafe destination address (address of the safe device). The address is assigned automatically. However, the value can be modified. Make sure that the value set under F_Destination_Address and the value that you have set via the 10-pos. DIP switch are the same. Value range: 1 ... 1022
F_WD_Time	150	Monitoring time in the safety module. A valid current safety telegram must arrive from the safe controller within the monitoring time. Otherwise, the safety module enters the safe state. The selected monitoring time must be sufficiently high for telegram delays to be tolerated by the communication, but still ensure a sufficiently fast error response in the event of an error (e.g., interruption in communication). Value range: 1 ... 65534, in 1 ms increments Unit: ms
F_SIL	*SIL 3*	Safety integrity (SIL according to IEC 61508) of the safety module **WARNING:** Safety functions up to SIL 3 can be achieved with the safety module. The safety integrity level that can actually be achieved depends on the parameterization, the structure of the sensor, and the cable installation (see "Connection examples for safe inputs" on page 7-1).
F_CRC_Length	*3-byte CRC*	This parameter transmits the length of the CRC2 code to be expected in the safety telegram to the safe controller.

Table B-1 Overview of the F-Parameters for the module

F-Parameter	Default value	Description
F_Block_ID	*1*	Parameter block type identification 1: The parameter block of the F-Parameters contains the F_iPar_CRC parameter.
F_Par_Version	*1*	Version number of the F-Parameter block. 1: Valid for V2 mode
F_iPar_CRC	0	CRC checksum via the iParameters The value must be greater than 0. When verifying the safety function, check whether the F_iPar_CRC parameter is greater than 0 for all devices. If not, check the iParameters and the CRC checksum in the iParameter and F-Parameter.

B 2 iParameters

The iParameters are individual device parameters. These include:

– Device parameters (see "Parameterization of the safe inputs" and "Parameterization of clock outputs UT1 and UT2")
– PST_Device_ID (10_{hex} for IC220SDL543)
– F_Destination_Address (not included in the checksum calculation)

iPar_CRC The device parameters are verified with a checksum: iPar_CRC.

F_Destination_Address This address is the PROFIsafe address of the module. Make sure that it matches the switch position of the 10-pos. DIP switch.

B 3 Diagnostic messages for parameter errors

B 3.1 Diagnostic messages for F-Parameters and iParameters for PROFIsafe

Table B-2 F-Parameter parameter errors

Error code		Error cause	Remedy
dec	**hex**		
64	40	The parameterized F_Destination_Address does not match the PROFIsafe address set on the safety module (F-Module).	Make sure that the PROFIsafe address of the safety module and the value in F_Destination_Address are the same.
65	41	Invalid parameterization of F_Destination_Address. Addresses 0000_{hex} and $FFFF_{hex}$ are not permitted.	Correct value.
66	42	Invalid parameterization of F_Source_Address. Addresses 0000_{hex} and $FFFF_{hex}$ are not permitted.	Correct value.
67	43	Invalid parameterization of F_WD_Time. A monitoring time of 0 ms is not permitted.	Correct value.
68	44	Invalid parameterization of F_SIL. The safety module (F-Module) cannot support the required SIL.	Use a device with the required SIL. The safety module achieves SIL 3, maximum.
69	45	Invalid parameterization of F_CRC_Length. The CRC length generated by the safety module (F-Module) does not match the required length.	Check device description.
70	46	Invalid F-Parameter record version. The safety module (F-Module) version does not match the required version.	Check device description. Only V2 mode permitted.
71	47	The checksum determined by the safety module (F-Module) via the PROFIsafe parameters (CRC1) does not match the CRC1 transmitted in the parameter telegram.	Check F-Parameters, repeat calculation.
255	FF	During active process data communication, a new F-Parameter block was received, which differs from the F-Parameter block currently used. Incorrect type ID for the F-Parameter block (F_Block_ID).	Only send modified parameter data when process data communication is not active. Check device description.

Table B-3 iParameter parameter errors

Error code (hex)	Error cause	Remedy
03F2	iPar_CRC is incorrect	Check iParameters, repeat calculation.
03FA	iPar_CRC is not equal to F_iPar_CRC	Apply correct value.
03FB	PST_Device_ID is incorrect	Correct value (10_{hex} for IC220SDL543).
03FC	F_Destination_Address in the iParameters is incorrect	Correct value. Make sure that the value set under F_Destination_Address and the value that you have set via the 10-pos. DIP switch are the same.
03FD	Incorrect order of iParameter blocks	Check infrastructure components.

B 3.2 Diagnostic messages for parameter errors for VersaSafe

Table B-4 Parameter errors

VersaSafe error code		Error cause	Remedy
dec	hex		
1088	440	VersaSafe: The parameterized VersaSafe address does not match the address set on the safety module.	Make sure that the addresses are the same.
1089 ... 1094	441 ... 446	Internal errors	Please contact GE Intelligent Platforms.
1095	447	The configurable safety module detected a distortion in the configuration and parameter data record.	Attempt transmission again. If the error occurs permanently, the data record in the controller is distorted. In this case, you can get VersaConf Safety to generate a new data record.

C Appendix: Checklists

The checklists listed in this section provide support during the planning, assembly and electrical installation, startup, parameterization, and validation of the IC220SDL543 module.

These checklists may be used as planning documentation and/or as verification to ensure the steps in the specified phases are carried out carefully.

Archive the completed checklists to use as reference for recurring tests.

The checklists do not replace the validation, initial startup, and regular testing performed by qualified personnel.

The following section of a checklist shows an example of a completed checklist.

Checklist . . .					
Device type/equipment identification		IC220SDL543/BK20NA10			
Version: HW/FW	00/200	**Date**	January 1, 2008		
Test engineer 1	John Smith	**Test engineer 2**	Jane Brown		
Remark	System XXX has been checked for engine hood production				
No.	**Requirement (mandatory)**	**Yes**		**Remark**	
X	. . .	☐			
No.	**Requirement (optional)**	**Yes**	**No**	**Remark**	
Y	. . .	☐	☐		

Key:

Equipment identification	Enter the device type and/or the equipment identification for the relevant device.
Version: HW/FW	Enter the hardware and firmware version of the device (see "Structure of the safety module" on page 2-2).
Date	Enter the date on which you began to fill in this checklist.
Test engineer 1/2	Enter the names of the test engineers.
Remark	Enter a remark, if necessary.
Requirement (mandatory)	These requirements must be met for a safety application, in order to complete the relevant phase using the checklist.
Requirement (optional)	These requirements are optional. For points that are not met, please enter an appropriate remark in the relevant field.

C

C 1 Planning

Checklist for planning the use of the safety module			
Device type/equipment identification			
Version: HW/FW		**Date**	
Test engineer 1		**Test engineer 2**	
Remark			

No.	Requirement (mandatory)	Yes	Remark
1	Has the current module user manual been used as the basis for planning?	☐	Revision:
2	Are the sensors approved for connection to the module (according to the technical data and parameterization options)?	☐	
3	Has the voltage supply been planned according to the specifications for the protective extra-low voltage in accordance with PELV?	☐	
4	Is external fuse protection of the module planned (according to the specifications in this user manual for supply voltage U_M)?	☐	
5	Are measures planned to prevent simple manipulation?	☐	
6	Are measures planned to prevent connectors being mixed up?	☐	
7	Are requirements for the sensors and cable installation observed according to the SIL/SIL CL/Cat./PL to be achieved and is the corresponding implementation planned?	☐	
8	Are the specifications for the parameterization for each channel specified?	☐	
9	Has it been ensured that any person intentionally starting hazardous movements has a direct view of the danger zone?	☐	
10	Does the planned use correspond to the intended use?	☐	
11	Are the ambient conditions observed according to the technical data?	☐	
12	Have test intervals been defined?	☐	

No.	Requirement (optional)	Yes	No	Remark
13	Have the accessories to be used been planned according to the ordering data in this user manual (cables, connectors)?	☐	☐	
14	Have specifications for assembly and electrical installation been defined (e.g., EPLAN) and communicated to the relevant personnel?	☐	☐	
15	Have specifications for startup been defined and communicated to the relevant personnel?	☐	☐	

Date	Signature (test engineer 1)
Date	Signature (test engineer 2)

C 2 Assembly and electrical installation

Checklist for assembly and electrical installation of the safety module			
Device type/equipment identification			
Version: HW/FW		**Date**	
Test engineer 1		**Test engineer 2**	
Remark			

No.	Requirement (mandatory)	Yes	Remark
1	Was assembly completed according to the specifications (specifications from the planning phase or according to the user manual)?	☐	
2	Was the safety module installed in the control cabinet (IP54)?	☐	
3	Do the cable cross sections correspond to the specifications?	☐	

No.	Requirement (optional)	Yes	No	Remark
4	Is the transmission speed and the operating mode set correctly according to the specifications?	☐	☐	
5	Is the protocol/address set correctly according to the specifications?	☐	☐	

Date	Signature (test engineer 1)
Date	Signature (test engineer 2)

C 3 Startup and parameterization

Checklist for startup and parameterization of the safety module			
Device type/equipment identification			
Version: HW/FW		**Date**	
Test engineer 1		**Test engineer 2**	
Remark			

No.	Requirement (mandatory)	Yes	Remark
1	Was startup completed according to the specifications (specifications from the planning phase or according to the user manual)?	☐	
2	During startup, is it ensured that any person starting hazardous movements intentionally can only do so with a direct view of the danger zone?	☐	
3	Are all parameters parameterized for the inputs?	☐	
4	For inputs that are parameterized for two-channel operation, are both channels parameterized correctly for each other?	☐	
5	Is the assignment to the clock outputs parameterized for the inputs?	☐	
6	Are the clock outputs parameterized?	☐	

No.	Requirement (optional)	Yes	No	Remark
7	Are safety distances that must be observed calculated according to the response and delay times implemented?	☐	☐	

Date	Signature (test engineer 1)
Date	Signature (test engineer 2)

C 4 Validation

Checklist for validating the safety module			
Device type/equipment identification			
Version: HW/FW		**Date**	
Test engineer 1		**Test engineer 2**	
Remark			

No.	Requirement (mandatory)	Yes	Remark
1	Have all the mandatory requirements for the "Planning" checklist been met?	☐	
2	Have all the mandatory requirements for the "Assembly and electrical installation" checklist been met?	☐	
3	Have all the mandatory requirements for the "Startup and parameterization" checklist been met?	☐	
4	Does the parameterization of the safe inputs and clock outputs correspond to the version and the actual connection of the controlling device?	☐	
5	Has the assignment of the sensors to the inputs and the variables of the safe application program been tested (also as online status in SafetyProg)?	☐	
6	Has a function test been performed to check all safety functions, in which the module is involved?	☐	
7	Have measures been taken to achieve a specific Cat.?	☐	
8	Do all cables correspond to the specifications?	☐	
9	Does the voltage supply correspond to the specifications for the protective extra-low voltage in accordance with PELV?	☐	
10	Is external fuse protection of the module implemented (according to the specifications in this user manual for supply voltage UM)?	☐	
11	Have measures been taken to prevent simple manipulation?	☐	
12	Have measures been taken to prevent connectors being mixed up?	☐	
13	Are the requirements for the sensors and cable installation observed according to the SIL/SIL CL/Cat./PL to be achieved?	☐	
14	Are the specifications for the parameterization for each channel implemented?	☐	
15	For PROFIsafe: Is the F_iPar_CRC parameter greater than 0 for all devices?	☐	
16	Has it been ensured that any person intentionally starting hazardous movements has a direct view of the danger zone?	☐	
		Date	Signature (test engineer 1)
		Date	Signature (test engineer 2)

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